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VOLUME 8 NUMBER 5

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CONTENTS OF PREVIOUS NUMBERS

SEPTEMBER, 1922. NUMBER 3

Visual Defects Caused by Occipital Lobe Lesions: Report of Thirteen Cases. H. W. Scarlett, M.D., Philadelphia, and S. D. Ingham, M.D., Los Angeles.

Electromyographic Studies of Paralysis Agitans. Stanley Cobb, M.D., Boston.

A Consideration of the Dermal Versus the Epidermal Cholesteatomas Having Their Attachment in the Cerebral Envelopes. Gilbert Horrax, M.D., Boston.

Epidemic (Lethargic) Encephalitis: Cultural and Experimental Studies. Second Communication. William Thalhimer, M.D., Milwaukee.

Abstracts from Current Literature:

General Consideration of Encephalitis.—Pictures of Paralysis Agitans and Tetany Within the Scope of Arteriosclerosis.—Microptic Hallucinations.—Spina Bifida Occulta and Sciatica.—Development of the Amphibian Nervous System.—Disorders of Sensation in Paralyses of the Facial Nerve.—The Diagnosis of Hysteria.—Radicular Distribution of Nevi and Vitiligo.—Semeiology of Involuntary Rhythmic Movements in Epidemic Encephalitis.—Influence of the Lateral Line System on the Peripheral Osseous Elements of Fishes and Amphibia.—Comparative Studies in Other Fishes of Cells That Are Homologous to the Large Irregular Glandular Cells in the Spinal Cord of the Skates.—Muscular Twitchings in Epidemic Encephalitis.—Cytology of Large Nerve Cells of the Grayfish.—Motor Nuclei of Cerebral Nerves in Phylogeny.

Society Transactions:

New York Neurological Society.

Boston Society of Psychiatry and Neurology.

Philadelphia Neurological Society.

Book Reviews.

OCTOBER, 1922. NUMBER 4

Effects of Antisyphilitic Therapy as Indicated by the Histologic Study of the Cerebral Cortex in Cases of General Paresis. A Comparative Study of Forty-Two Cases. H. C. Solomon, M.D., Boston, and A. E. Taft, M.D. Philadelphia.

Progressive Funicular Myelopathy (Subacute Combined Degeneration). Joseph H. Globus, M.D., and Israel Strauss, M.D., New York.

Papilloma of the Fourth Ventricle: Report of a Case. Ernest Sachs, M.D., St. Louis.

Magnus and De Kleijn Phenomena in Brain Lesions of Man. A Consideration of These and Other Forced Attitudes in the So-Called Decerebrate Man. I. Leon Meyers, M.D., Los Angeles.

Diagnostic Value of Blood Sugar Curves in Neurology. Sidney I. Schwab, M.D., St. Louis.

Malignant Tumors of the Nasopharynx with Involvement of the Nervous System. Henry W. Woltman, M.D., Rochester, Minn.

Abstracts from Current Literature:

Dementia Afasica (Bianchi's Disease).—Sensation.—Physiology and Pathology of Tickling.—Pathological Studies in Dementia Praecox.—Pathology and Treatment of Spinal Cord Tumors.—Field Defects Produced by Temporal Lobe Lesions.—Cerebral and Unilateral Fever.—Sequelae of Epidemic (Lethargic) Encephalitis.—Pathogenesis of Disturbances of Sleep Following Encephalitis Lethargica.—Results of Fifty Decompressions for Epilepsy.—Mongolian Idiocy in a Chinese Boy.

Society Transactions:

Philadelphia Neurological Society.

Book Review.

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Archives of Neurology and Psychiatry

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AN ANALYSIS OF FOURTEEN CONSECUTIVE CASES OF SPINAL CORD TUMOR*

CHARLES H. FRAZIER, M.D., AND WILLIAM G. SPILLER, M.D.

PHILADELPHIA

While tumors of the spinal cord, the spinal roots or meninges are less frequent than tumors of the brain, in the ratio of 1 to 6, the proportion of operable tumors of the cord from the standpoint of localization and facility of removal is greater than that of tumors of the brain. In twelve of the fourteen consecutive cases chosen for review, the tumor was accessible, not difficult of localization, well encapsulated and distinctly an operable lesion. The ratio of spinal tumors to tumors at large is about 1 to 50 (Schlesinger). Perhaps because of their relative infrequency, they are often overlooked; and years may elapse before the true nature of the lesion is recognized. In many instances the pain of which the patient complains is attributed to a lesion in the territory to which the pain is referred. Neuralgia, neuritis, rheumatism if in the neighborhood of a joint, angina, gallbladder disease and diseases of other abdominal organs have been held accountable for the pain of a spinal tumor, and not infrequently abdominal operations have been performed under one of these mistaken diagnoses.

Whatever the cause, in the series under discussion the final diagnosis was not established until an average of 2 3/5 years had elapsed from the date of the initial symptom. The elapsed time in the individual cases was as follows: One case, 9 months; one case, 10 months; one case, 1 year; one case, 13 months; one case, 16 months; two cases, 2 years; three cases, 3 years; one case, 4 years, and three cases, 5 years. Of the fourteen cases of spinal cord tumor presented, ten occurred in women and four in men from 18 to 64 years of age. Ten were between 30 and 50 years, two were over 60, and of the remaining, one was 18 and one 29 years of age. As to location: Nine were extramedullary and subdural, two were extradural, one was a caudal tumor, one a tumor of the vertebral column, one was partly spinal and partly intra-

* Read before the Section on Nervous and Mental Diseases at the Seventy-Third Annual Session of the American Medical Association, St. Louis, May, 1922.

cranial. As to segmental location: Six involved the cervical segments, three the upper thoracic, four the lower thoracic and one the cauda equina.

In reviewing our cases with respect to sequence of symptoms, we find that in thirteen of the fourteen cases the first symptom was pain; and in the single exception, the tumor was extradural, and at no time throughout the course of the disease did the patient complain of pain. The constancy of pain, not only as the initial symptom, but as a con-

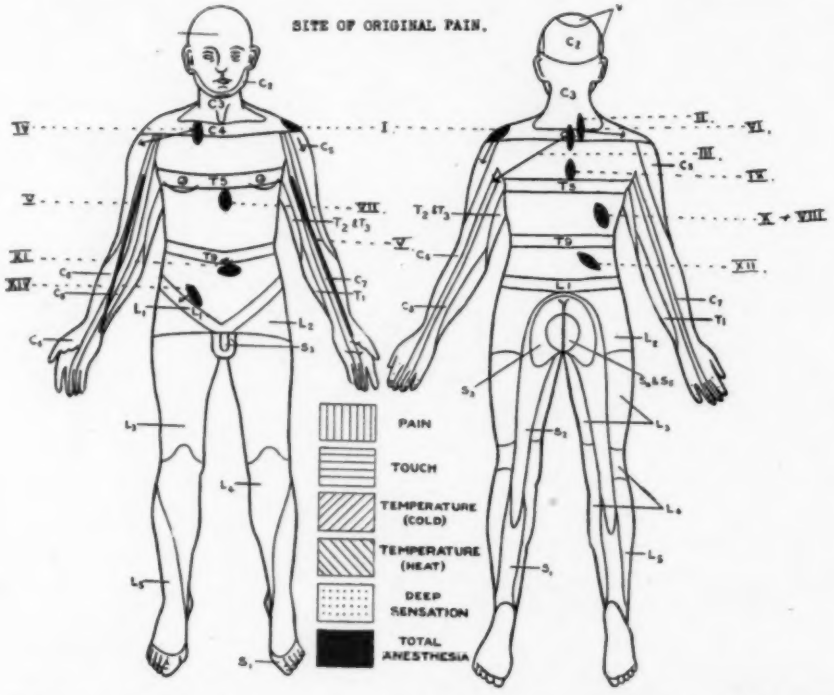

Fig. 1.—Representation of location of the points to which the pain was referred as the initial and a constant symptom in thirteen of the fourteen cases of the series.

spicuous symptom, was so striking we were surprised to read that, in the experience of another writer,[1] "the majority of patients with spinal lesions do not have any severe pain during their illness and only the occasional case has any whatsoever;" and "to wait for the development of pain in order to make a positive diagnosis of spinal tumor is as great a fallacy as to require the presence of headache, vomiting and choked disc for the diagnosis of brain tumor." Of course it is well known that spinal cord tumors may run a painless course. Cases of

1. Sachs, Ernest: J. Missouri M. A., April, 1919.

this character have been reviewed by Oppenheim, Bailey, Clarke and Schultze. The location of the tumor with relation to the roots would of course affect the incidence of pain.

The pain was first observed at one more or less definitely localized point, almost invariably at a level corresponding to the segment involved (Fig. 1), and was described variously as tearing, burning, as a "knife," or as a dull ache, never as lancinating or shooting in character. It was often intermittent with intervals of freedom of days or months, and often worse at night or in the early morning. Especially in tumors of the cervical cord was it aggravated by movements of the neck or arms. In several instances, there was an appreciable subsidence of pain at the onset of paralysis. Errors in diagnosis were influenced by the location of the pain. Several of the cervical cord lesions had been

TABLE 1.—TIME BETWEEN PAIN AND FIRST SIGNS OF MOTOR IMPAIRMENT*

Case	Duration of Pain	Duration of Motor Impairment	Interval Between Onset of Pain and Motor Impairment
1	5 years	2 years	3 years
2	9 months	3 months	6 months
3	1¼ years	6 months	6 months
4	2 years	1 month	2 years
5	9 months	6 months	3 months
6	2 years	4 months	1⅔ years
7	5 years	2 years	3 years
8	4 years	2 years	2 years
9	3 years	2 months	2¾ years
10	1¼ years	3 months	1 year
11	6 years	1½ years	4½ years
12	1 year	6 months	6 months
13	0 years	2 years	
14	3 years	3 months	2¾ years

* In six cases three or more years had elapsed, in two cases two years, in two cases between one and two years, and in three cases less than a year. This relationship is expressed in graphic form in Figure 2.

erroneously diagnosed as Pott's disease; "neuritis" was the diagnosis in practically all cases in which the shoulder or arm was involved; in one case with pain referred to the left precordial region the case was diagnosed as "angina;" in one case with pain referred to the abdomen as gallstones; in another, to the lower extremities, as sciatica. Hysteria was not an infrequent diagnosis but was more common when pain was referred to the lower than to the upper extremities.

Table 1 indicates the time which elapsed between the onset of pain and the first signs of motor impairment.

We have dwelt on the pain phenomenon because of its outstanding importance as a warning in spinal tumors. Given a case with pain of definite localization, persisting without variation except in degree, in its original territory for months, and especially for longer periods, one should at least have in mind the possibility of spinal tumor and be on the lookout for further confirmatory evidence, such as paresthesias, hyperesthesis, anesthesia, disturbance of reflexes and motor impairment

(Fig. 3). But pain alone, even though localized for a considerable time, may be caused by radiculitis or meningomyelitis, and we must wait for the development of other symptoms before operation is justifiable. Pain associated with atrophy in root distribution of the upper limb should arouse the suspicion of tumor, and yet if roentgen-ray examination reveals no pathologic condition it seems to us as a general rule advisable to defer operation until some clinical evidence of implication of the cord is obtained. Exaggeration of the tendon reflexes of the lower limb, especially if associated with the Babinski reflex, on the

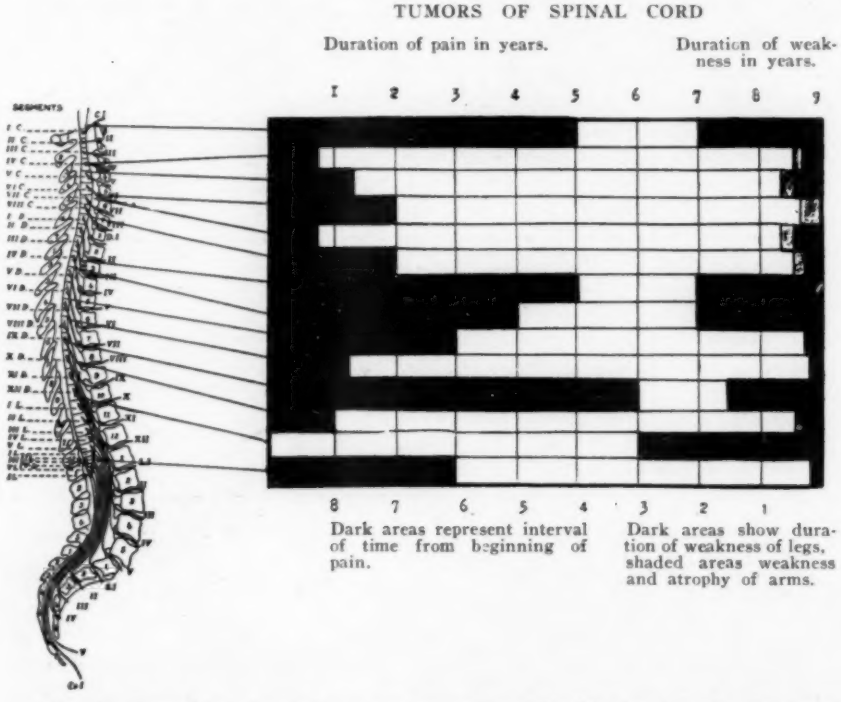
TUMORS OF SPINAL CORD
Duration of pain in years.
Duration of weakness in years.
1 2 3 4 5 6 7 8 9
8 7 6 5 4 3 2 1
Dark areas represent interval of time from beginning of pain.
Dark areas show duration of weakness of legs, shaded areas weakness and atrophy of arms.

Fig. 2.—Duration of pain in years as compared with the duration of motor impairment in the individual tumor cases of this series.

same side as the pain and atrophy of the upper limb, is a combination that may justify early operation. Should in addition to this a diminution of pain and temperature sensations be found in the lower limb of the opposite side, operation, under ordinary circumstances, should be performed.

This interesting phenomenon was observed in Case 6. Before the operation the prick of a pin in the sole of the left foot would produce a vigorous reflex of defense in the left lower limb, such as could not be obtained from the contact with the head of the pin or by touching

the sole with the finger. In these parts objective pain sensation was entirely lost, although the patient could distinguish the point of the pin from the head because the prick of the pin was "unpleasant," and yet this "unpleasantness" was not intense. The interest of the observation lies in the fact that the reflex of defense was active for stimuli

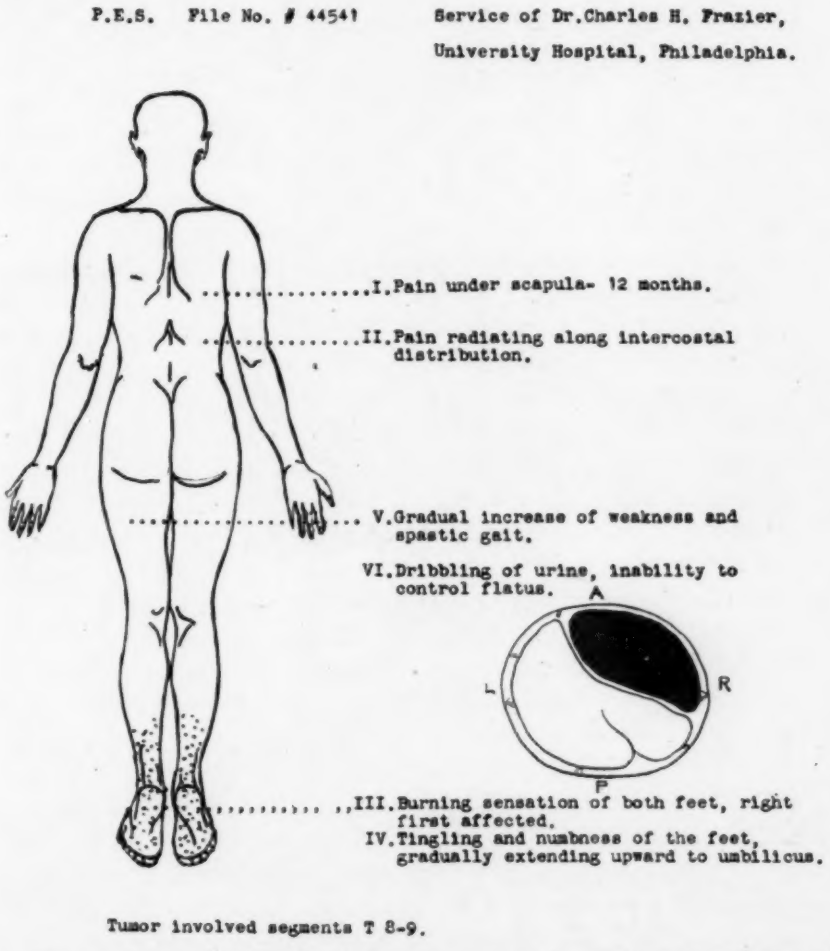
P.E.S. File No. # 44541
Service of Dr.Charles H. Frazier,
University Hospital, Philadelphia.
I.Pain under scapula- 12 months.
II.Pain radiating along intercostal distribution.
V.Gradual increase of weakness and spastic gait.
VI.Dribbling of urine, inability to control flatus.
A
L
R
P
III.Burning sensation of both feet, right first affected.
IV.Tingling and numbness of the feet, gradually extending upward to umbilicus.
Tumor involved segments T 8-9.

Fig. 3.—Representation of the usual sequence of symptoms in spinal cord tumors; namely, pain, paresthesias, motor impairment.

which normally produce pain, although the perception of pain was abolished. These stimuli in this case were capable of exerting their effect on the motor nerve cells of the lumbar region, but as the break in the pain conduction was in the cervical region the brain was not capable of recognition of painful stimuli. This observation was not peculiar to this case and has been confirmed by us in the examination

of another case. Irritation of fibers of pain as by slight pin prick is a very satisfactory way of obtaining the reflex of defense. These observations have physiologic importance. In cases in which it is desirable to increase the activity of the nerve cells of the anterior horn of the spinal cord, even when analgesia or hypalgesia exists, mild stimuli which normally produce pain, such as pin prick, may be of value in addition to massage or electricity.

PARESTHESIAS

While the pain, present in all but one case, was the first symptom, other subjective sensory disturbance was invariably the second symptom, preceding in all cases, when present, any motor disturbance (Table 2). Four patients described a sense of numbness; two in one upper extremity (Cases 2 and 4) and two in one leg and foot (Cases 3 and 7); it may be noted that in three cases (2, 3 and 4) the numbness was on the same side and in one (Case 7) on the side opposite a tumor situated anterolateral to the cord. Elsberg states that in five anterolateral tumors of his series there was paresthesia in the lower contralateral limb.

In the remaining cases the sensation was described as stinging (Case 6), burning (Cases 8, 9, 10, 11), itching (Case 14), tingling (Cases 10, 13), a sense of constriction about the knee (Case 10), of pressure or a tight jacket about the trunk (Case 12) and as a sleepy feeling in the fingers (Case 6). In no case did pressure on the cord cause severe pain in the portions of the body innervated from the spinal cord below the tumor. This is important in regard to Gordon Holmes' views on pain produced by lesions of the cord substance. Pain from intramedullary or extramedullary spinal lesions not implicating roots must certainly be regarded as uncommon.

The Brown-Séquard syndrome in the classical symptomatology of spinal tumors is represented as the second of the three cycles, the first being the root cycle and the third that of paralysis of motor and sensory functions. If one were able to examine the patient at all times in the life history of the tumor there might be a time when in the majority the Brown-Séquard syndrome could be detected. But in our series in only five out of fourteen were there unilateral sensory phenomena, and these not of the classical Brown-Séquard type. In three there was no sensory blunting, and in the remainder the loss or impairment of sensation had a bilateral distribution. One would expect to see this syndrome only when the tumor is situated on the lateral aspect of the cord. In five cases, where the sensory disturbances were unilateral, the tumor was recorded as contralateral in four cases and posterior in one.

When the sensory loss was present on both sides, the location of the tumor was recorded as posterior in three, caudal in one, and right anterolateral in two.

Motor disturbances were present in greater or less degree in most cases. There were, however, exceptions. Under conditions quite comparable as far as one could see, one patient within nine months of the onset of symptoms had a disabling paraplegia; another, with a

TABLE 2.—DISTURBANCES OF SENSATION

Case	Location	Paresthesias	Loss or Impairment of Sensation
1	Left lateral C 1 C 2	Absent	Present: unilateral, contralateral
2	Right posterolateral C 4	Present: unilateral, hemolateral	Present: unilateral, contralateral
3	Left anterolateral C 4 C 5	Present: unilateral, hemolateral	Absent
4	Right anterolateral C 3 C 4	Absent	Present: bilateral
5	Right anterolateral T 3	Absent	Absent
6	Right anterolateral C 8 T 2	Present: unilateral, hemolateral	Present: unilateral, contralateral
7	Left lateral T 3 T 5	Present: unilateral, contralateral	Present: unilateral, contralateral
8	Posterior T 5 T 6	Present: unilateral	Present: unilateral
9	Posterior T 5 T 6	Present: bilateral	Present: bilateral
10	Right anterolateral T 8 T 9	Present: bilateral	Present: bilateral
11	Posterior T 10	Present: central	Present: bilateral
12	Right lateral T 12	Present: unilateral, hemolateral	?
13	Posterior L 2 L 4	Present: bilateral	Present: bilateral
14	Caudal	Present: bilateral	Present: bilateral

TABLE 3.—MOTOR SYMPTOMS

Duration	Side	Location	Motor Disability	Left or Right
6 months	Left	Intradural	Spastic paraplegia	
5 months	Right	Intradural	Spastic paralysis	Right leg
2 years	Posterior	Intradural	Spastic paraplegia	
3 years	Posterior	Extradural	Spastic paraplegia	
2 years	Left	Intradural	Spastic weakness	Left leg
5 months	Right	Intradural	Paresis	Right leg
1½ years	Posterior	Intradural	Spastic paraplegia	
2 weeks	.....	Caudal		
2 years	Left	Intradural	Spastic paraplegia	
5 months	Right	Vertebral	Spastic paraplegia	
2 months	Right	Intradural	Spastic weakness	Right and left legs
4 months	Left	Intradural	weakness	Left leg
7 months	Right	Intradural	Spastic paralysis	Right arm
3 months	Posterior	Extradural	Spastic paraplegia	

tumor of equal dimensions, was still able to walk with comparative ease four years after the onset of symptoms. Table 3 shows the motor symptoms, duration of lesion and relation of the tumor to the cord.

In only two of the fourteen cases was there disability in the upper extremity; in half of the cases both lower extremities were involved, and in the remaining only one. The development of motor disability was in most instances (nine out of fourteen) a matter of weeks or months. This is in rather striking contrast to the period of root pains, which averaged two years. In other words, when the tumor had

increased sufficiently in size to cause cord compression the motor phenomena developed rapidly.

With the history of root pains, followed by sensory disturbances, paresthesias and anesthesias and later by motor impairment, the diagnosis of spinal tumor was established with a reasonable degree of certainty. There was only one exception, a patient who at no time during the three years she had had a tumor had complained of pain. Prior to her admission this patient had been treated for myelitis and operation considered inappropriate largely because of the absence of pain phenomena. But the spastic paraplegia plus the loss of pain and temperature sensations below a given level was considered sufficient evidence to warrant an exploratory laminectomy, at which a large extradural tumor was found (Fig. 4).

Fig. 4.—Extradural tumor removed at operation from a patient who at no time throughout the illness of two and one-half years complained of pain.

Much stress is laid on the presence or absence of signs of spinal block. In this series there were only five patients with the xanthochromia phenomenon, and in these the duration of the lesion was five years, four years, three years, 1 year and 9 months, respectively. Quite recently Queckenstedt introduced a test for spinal block by observing whether the pressure in the lumbar puncture manometer is affected by compression on the internal jugular veins. Had this test been applied in all our cases it is quite possible that the signs of block might have been elicited in a larger percentage than by the xanthochromia test. At all events, a positive finding by either method should be regarded only as confirmatory evidence of tumor, since negative

findings do not preclude the possibility of tumor and positive findings have been noted in lesions other than tumor.

In six cases there was disordered function of bladder and bowel (Cases 1, 4, 5, 8, 9 and 10). In five of the six there was difficulty in urination and in one (Case 9) there was occasional incontinence of urine. There was constipation in three (Cases 4, 5 and 9) and bowel incontinence in two (Cases 8 and 10).

SEGMENTAL DIAGNOSIS

Here may be taken into consideration referred pain, sensory disturbances, muscle atrophy or impaired power and disturbed reflexes. Table 4 gives the relationship between the region to which pain was first referred and the level of the tumor.

From this phenomenon alone accurate localization of the level of the tumor would be possible in the majority of cases. Pain was

TABLE 4.—RELATIONSHIP BETWEEN REGION TO WHICH PAIN WAS REFERRED AND LEVEL OF TUMOR

Left shoulder	C 5 C 6 (left) C 1 C 2 (left)
Right shoulder	C 4 C 5 (right) C 4 (right)
Between shoulders	C 8 T 1 T 2 (right) T 1 T 5 (posterior)
Between angle of scapula	T 7 T 10 (right)
Right and left arm	C 8 T 1 T 2 (left)
Around chest	T 3 T 5 (left)
Back	T 4 T 7 (posterior) T 9 T 11 (right)
Epigastrium	T 8 T 11 (left)
Right leg	Caudal

referred: (1) to the shoulder where the tumor was found in the fourth, fifth or sixth cervical segments; (2) to the upper extremities in involvement of the eighth cervical and first and second thoracic segments; (3) between the shoulders in involvement of the eighth cervical and first five thoracic segments; (4) around the chest in involvement of the third, fourth and fifth thoracic segments; (5) to the epigastrium from the eighth to eleventh thoracic segments; (6) to the back from the fourth to eleventh thoracic; (7) to the leg from the cauda equina.

In one case pain was referred to the shoulder when the tumor was chiefly on the medulla oblongata (Fig. 5), although the uppermost cervical segments were involved. The patient (Case 1) had complained for five years of pain in her left shoulder, and to a less extent in the left upper limb. The left shoulder had become atrophied during three years. Pain is not always strictly confined to the distribution of the nerve or nerve roots irritated; it seems to radiate into adjoining ter-

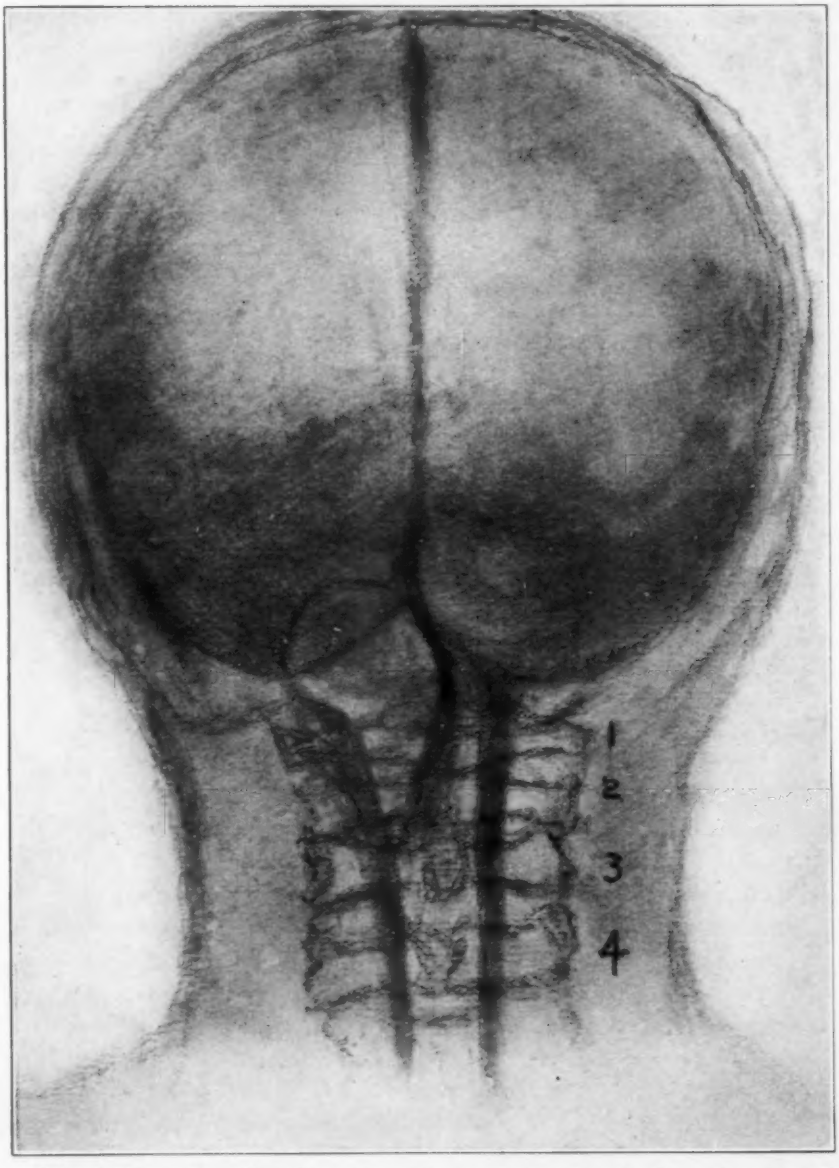

Fig. 5 (Case 1).—Situation of a tumor partly in the spinal canal and partly within the posterior fossa.

ritories, but it is striking that pain should be felt in the shoulder and down the upper limb when the tumor is confined to the first and second cervical segments. The third cervical segment gives pain fibers to the greater part of the neck and the fourth cervical to the upper part of the limb over the shoulder; and a tumor high on the cord possibly may interfere with adjoining segments below by circulatory disturbances, edema or other means. We would raise the question whether irritation

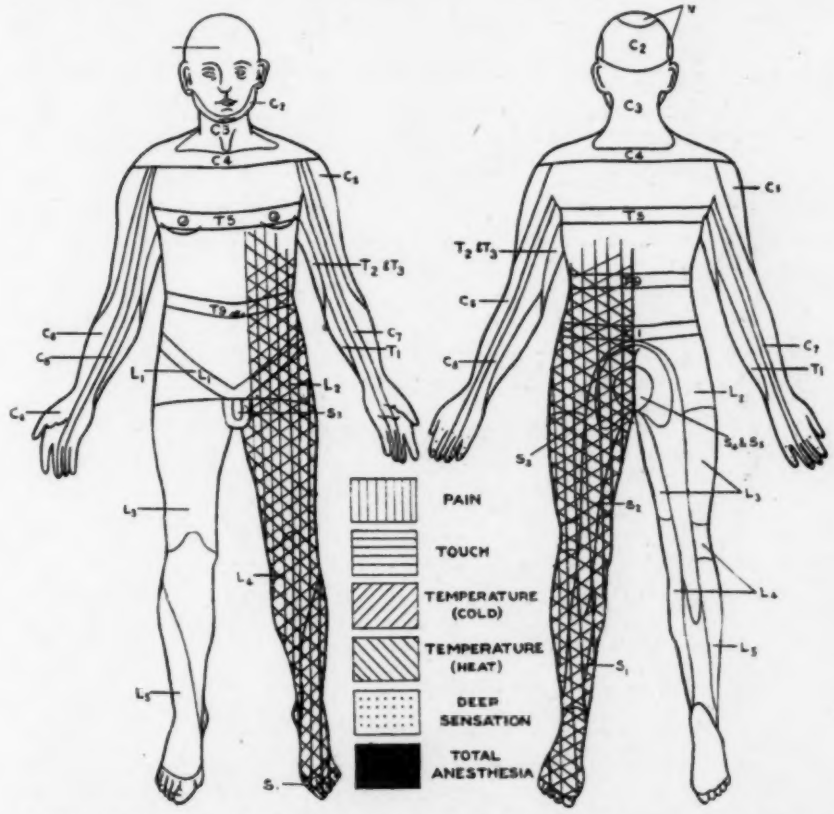

Fig. 6 (Case 2).—Unilateral loss of pain and temperature sense in a case of extramedullary tumor on the right anterolateral aspect of the cord at the level of the fourth cervical segment.

of the spinal accessory nerve in its course upward before leaving the cranium may not be the cause of pain referred toward the shoulder, and whether in the same way atrophy of the trapezius muscle may not be in part responsible for the atrophy attributed to the shoulder.

It is unusual that the level diagnosis is not determined by the upper limits of impairment or loss of sensation and one should be able to chart with great precision the level of sensory disturbance before the segmental diagnosis is made (Fig. 6). In eleven of fourteen cases the

level of the lesion was accurately determined in this way. In segmental diagnosis ocular phenomena are of great localizing importance. There may be some question as to the lowest limit of sympathetic representation for the face, but when the sympathetic phenomena are present one may presuppose a tumor of the lower cervical or the upper thoracic

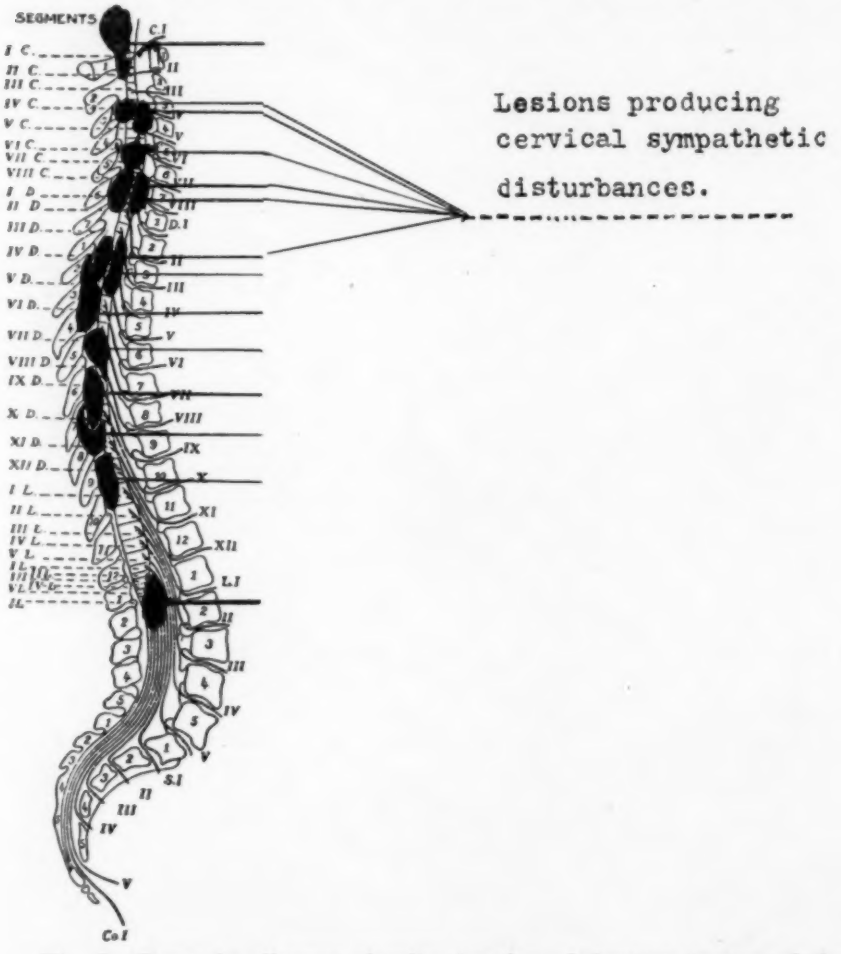

Fig. 7.—Composite diagram showing location of fourteen tumors of the series as to segmental level. Note that all the tumors from the third cervical to the first thoracic segment were associated with cervical sympathetic disturbances.

segments. In all our cases (six) in which the tumor was found from the fourth cervical to the third thoracic segment, these ocular phenomena of sympathetic origin were present (Fig. 7).

There were two instances in which sweating of the face was recorded, in one before and one after operation. In the latter (Case 5)

the tumor was situated in the neighborhood of the seventh and eighth cervical and first thoracic roots; in fact, the seventh cervical root passed over the middle of the tumor. Sweating in the right side of the face at times was marked, and ocular sympathetic phenomena were also noticed. These phenomena must have been traumatic, incidental to removal of the tumor.

In the other case there was almost constant sweating, even in cold weather, over the right orbit. The tumor was situated at the level of the sixth thoracic segment, lower than the segmental representation usually accorded the sympathetic, and sweating was probably caused by implication of the sympathetic fibers within the cervical cord by pressure.

It is a matter of little consequence once the segmental localization is made whether the tumor be intradural or extradural or what its position with relation to the cord, except perhaps an anterior location,

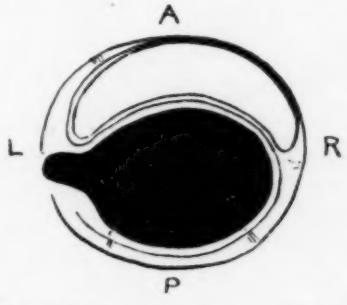

Fig. 8.—Diagrammatic representation of a tumor posterior to the cord in which the first symptom was one of motor impairment, showing effects of indirect pressure.

especially if it be extradural. Unless forewarned, a tumor in this location might be overlooked at operation. The absence of root pains in the early stages of tumor development point strongly to an anterior location. Likewise, early anterior root involvement would be of importance. In the majority of instances a lateral tumor may be presumed by the point to which pain is referred or by the Brown-Séquard syndrome, but contralateral symptoms may be produced as in at least one of our cases by pressure of the cord against the wall of the spinal canal on the side opposite the tumor (Case 13, Fig. 8). Bilateral pain from the beginning, as in Case 9, suggests a median posterior origin for the tumor; in this case the tumor was extradural.

The deep reflexes were almost without exception as one would have anticipated: they were apparently normal above the lesion, although possibly they were exaggerated, absent or subnormal when the tumor pressed on one or more segments corresponding to the level of the reflex

arc, and exaggerated below the level of the lesion. In one case the biceps and triceps reflexes seemed exaggerated when the tumor was at the ninth thoracic segment.

In the following cases the absence of reflexes was noted (Fig. 9): biceps reflex in a tumor at the level of the fourth cervical, abdominal

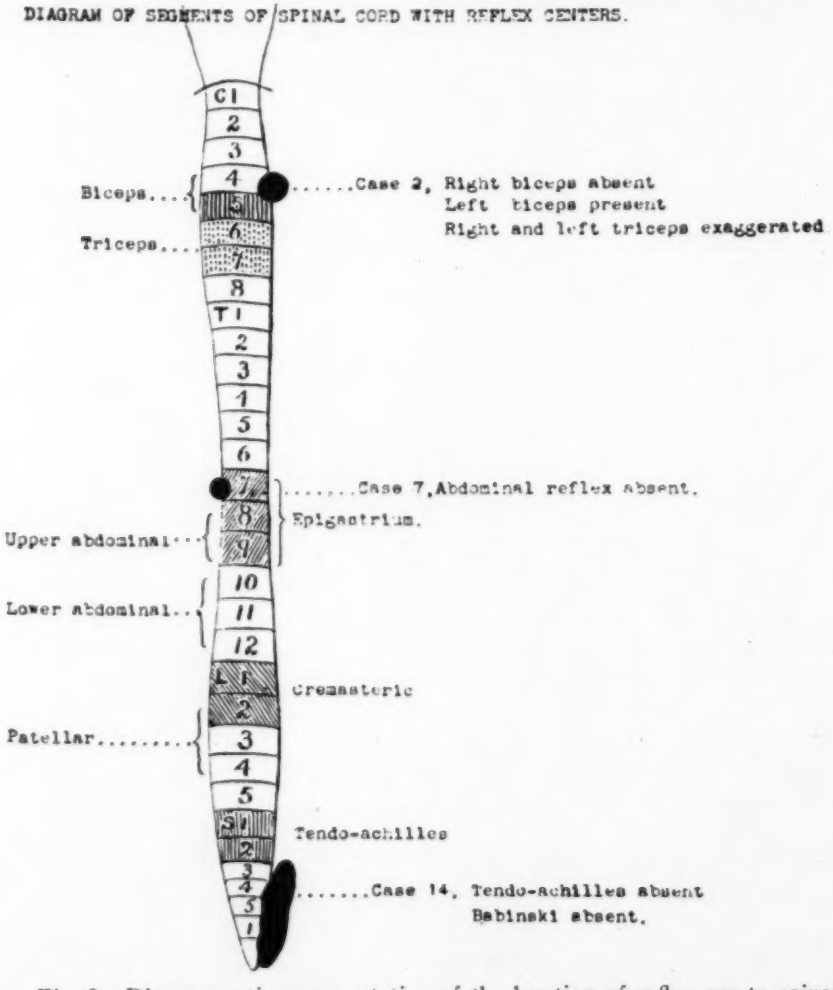

Fig. 9.—Diagrammatic representation of the location of reflex arc to spinal segments. The position of the tumor is indicated in three cases in which the localization was assisted by absence of an individual reflex.

reflex in a tumor at the level of the seventh thoracic, Achilles' tendon reflex in a tumor at the level of the terminal cord and cauda equina.

In one of these (Case 2) the biceps reflex was absent and the triceps reflex was exaggerated so that the localization of the tumor was placed definitely at the fourth or fifth thoracic segment, and at

this level the tumor was found. The reflex in this case was striking. Tapping the biceps tendon produced no flexion but caused pronation of the forearm. The reflex action was below the innervation of the fifth cervical segment, and this segment was incapable of originating a motor impulse; but the afferent fibers distributed to more than one segment were able to exert a functional control over muscles innervated from an adjoining region.

The Babinski reflex was recorded as present in eleven and absent in one of the fourteen cases. In three cases in which it was present on one side, it was always on the side of the tumor. While not of so much importance as the determination of the segment involved, one might state that the tumor is situated on the side on which this reflex is the more pronounced.

Disturbances in the movements of the diaphragm are significant as localizing symptoms. We noted only two instances (Cases 1 and 2). Perhaps others might have been detected had fluoroscopic examinations been made. There were four cases in which the tumor was found at or above the level of the fourth cervical segment, and in two of these the action of the diaphragm was disturbed. In one of these (Case 1) the fluoroscope revealed paralysis of one half the diaphragm and rather full movements of the other half. The tumor was situated at the first and second cervical (Fig. 4). In the other (Case 2) the tumor was found at the fourth cervical segment and "the left diaphragm appeared to move more than the right." Oppenheim thought that the diaphragm occasionally was less implicated than the location of the tumor would seem to make necessary. It seems that the diaphragm is not entirely dependent on the phrenic nerves for its function.

FUNCTIONAL RECOVERY

When there have been no degenerative changes in the cord, complete restoration of function may be anticipated. Considering the duration of the symptoms, one is surprised to see how soon after the operation improvement begins. In one of our series (Case 11) the history of tumor extended over a period of three years; the patient was quite helpless with a spastic paraplegia, and there was impairment of sensation up to Poupart's ligament. Within three weeks of the operation sensation was completely restored with the exception of an area of anesthesia on the left foot and ankle, and the patient could walk unaided about her room. Two weeks later she walked half a mile. In another (Case 5) there was complete paraplegia and total loss of sensation. Within six days of the operation there were signs of returning sensation, and soon after of motion, continuing to complete recovery.

In only two cases (7 and 11) was there absolutely no return of function. In one of these there was complete loss of motor and

sensory function, and the tumor history covered a period of five years. At the operation it was noted that the cord appeared as though degenerated, and an unfavorable prognosis was given. In the other, the result was not anticipated as the cord appeared normal. In this case a favorable prognosis was given, but a year after the operation signs of a complete transverse lesion presented. On the assumption that there might have been a recurrence, an exploratory operation was performed and the conditions presented were precisely those seen at the original operation after the removal of the growth. The cord had remained displaced to one side of the spinal canal, and the space formerly occupied by the tumor was readily recognized.

In the remaining cases, both motor and sensory function were almost completely reestablished within the year, although in some there were certain residual symptoms. For example, in one there was subjective sensory disturbance in the elbow and wrist; in another the grip of the hand on the affected side was weaker than the other, the reflexes continued exaggerated and there was a sensation of tightness about the left forefinger; in another, after a cervical laminectomy the patient complained of inability to hold the head erect. This was believed to be a functional disturbance.

SURGICAL PROBLEMS

Unlike tumors of the brain, exposure and removal of tumors of the spinal cord present simple elementary surgical problems. There are, to be sure, exceptions. But when the tumor is accurately localized, its exposure and removal are not difficult. Tumors anterior to the cord are, of course, less easily exposed than lateral and posterior ones. All of the tumors in our series were extramedullary, and the majority were endotheliomas or fibromas—tumors with definite encapsulation and limited in size by the dimensions of the canal.

In only one of the series was removal of the growth difficult (Case 1), and this was a tumor not only of the spinal canal but of the posterior fossa (Fig. 5). At least two thirds of the growth, a firmly fixed fibroma, was above the foramen magnum. In this case the removal might have been accomplished successfully had the situation not been seriously complicated by respiratory embarrassment. Before the operation the respiratory act was limited to one half of the diaphragm. The patient had had two attacks of respiratory embarrassment on her way to the hospital. The condition was quite desperate: before the tumor had been completely removed there was a respiratory breakdown, and attempts at resuscitation proved unavailing.

Exposure of the tumor was made by removal of three or four spinous processes and laminae, and in only one instance was it necessary

to enlarge the opening because the tumor extended beyond the limitations of our original opening. The cord may be rotated by traction on the dentate ligaments or gently retracted to afford adequate exposure. There is no difficulty in separating cord from tumor or tumor from cord. Only after the pia is divided is the line of demarcation clearly defined. Occasionally one root either anterior or posterior may be so incorporated in the tumor that its removal may seem desirable. In four of our cases (2, 4, 6 and 8) one posterior root was sacrificed and in one (Case 5) an anterior root.

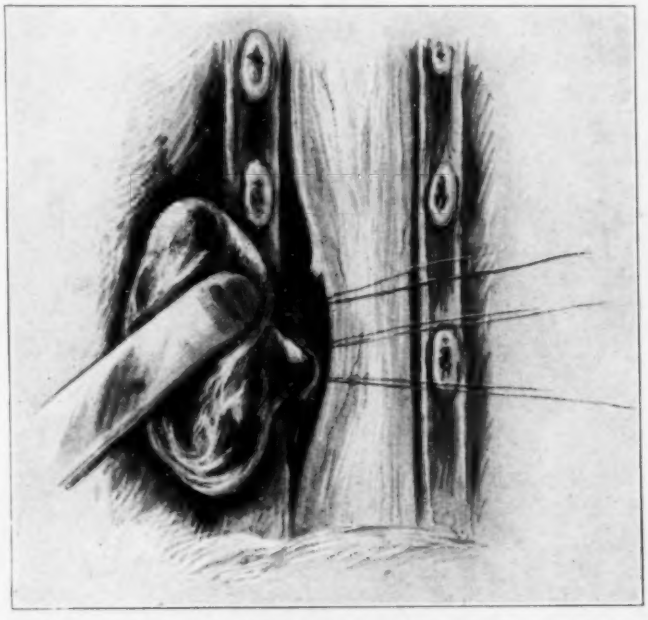

Fig. 10 (Case 9).—Extramedullary tumor in process of removal. Note the stalklike process emerging from the intervertebral foramen.

By blunt dissection the tumor is readily isolated at all points except at its point of origin or attachment. As to the origin of the endothelioma, there is some reason for believing that it originates from the spinal roots. That in some cases the roots had to be sacrificed might be advanced as circumstantial evidence. Furthermore, in two of our series (Cases 9 and 11), while the major portion of the tumor was posterior and extradural, there was a lateral extension, and in one case (Figs. 10 and 11) there was a distinct stalk, which was traced into the intervertebral foramen. In other cases the tumor was adherent to or perhaps incorporated in the dura at the lateral aspect of the spinal canal in close proximity to the point of exit of the roots from

the spinal canal. In one instance (Case 5) the tumor evidently had extended beyond the dura and invaded the vertebra. The close adherence of the tumor to the dura, and possibly the invasion of the dura, makes it advisable to remove that section of the dura to which the tumor is firmly attached. Hemorrhage from this area is quite free

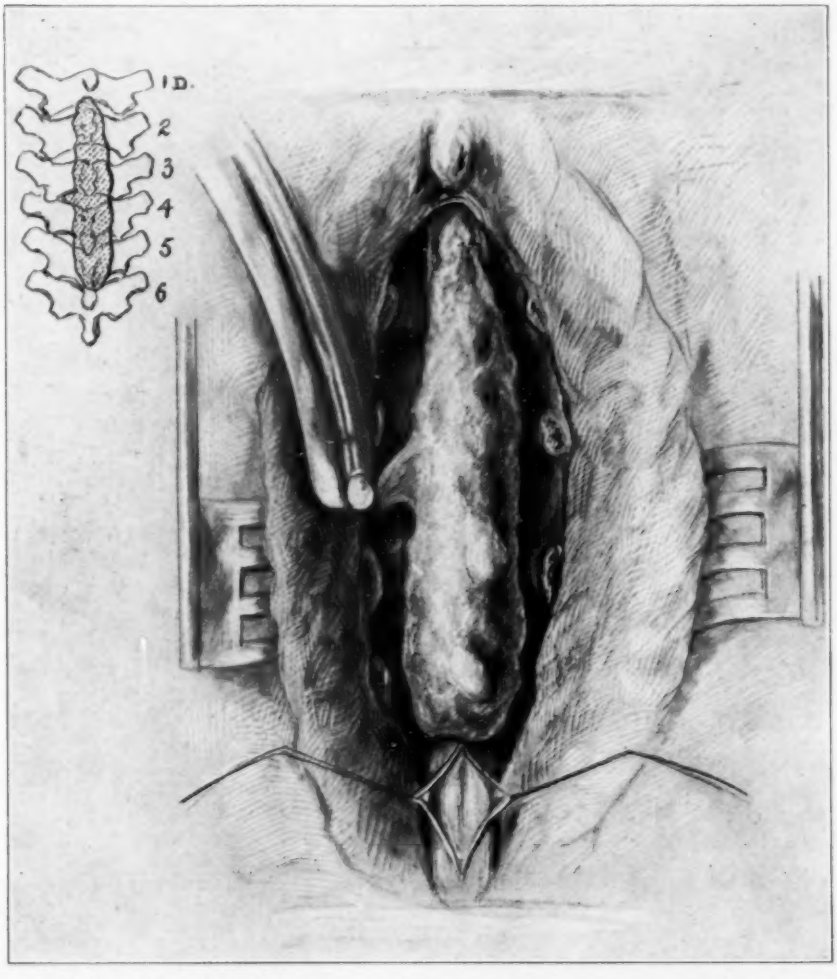

Fig. 11 (Case 11).—Large extradural tumor. Note process on left lateral aspect, presumably the point of origin.

and can be controlled only with muscle grafts. With this exception, the operation should be conducted in a bloodless field. After removal of the growth, the dural wound should be closed with a continuous silk suture, and the muscle-aponeurotic structures, subcutaneous tissue and skin with tier sutures.

REPORT OF CASES

CASE 1.—*History.*—Mrs. E. M., aged 47 years, referred to the neurosurgical service of the University Hospital, Nov. 17, 1921, by Dr. Thomas Hale, for five years had complained of neuralgic pains in her left shoulder and to a less extent in her left arm. Atrophy of her left shoulder had progressed for the last three years. For the past two years she has had difficulty in walking and now is unable to use her lower limbs. For the last three or four months she has noticed difficulty in breathing, and at the time of admission she was exceedingly dyspneic and had to be propped up in bed. There was no bladder or rectal incontinence, but some difficulty in urination.

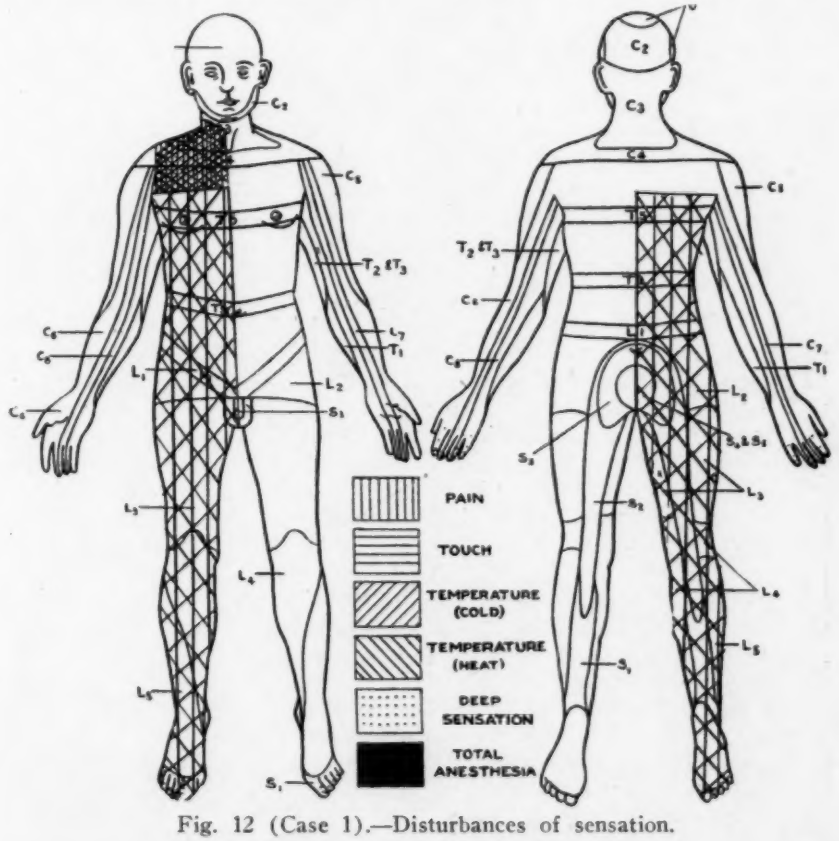

Fig. 12 (Case 1).—Disturbances of sensation.

Examination (Dr. Spiller).—Over the right side of the chest up to the second intercostal space she recognized pin-prick and ice water, but over the right side of the neck up to about 1 inch from the lower border of the maxilla she recognized neither pin-prick, heat nor cold, but she recognized touch in this area as well as over the right side of the chest; i. e., she had sensory dissociation as high as the second or third cervical segment (Fig. 12). The pupils were equal, dilated and reacted promptly. The paralysis of the left upper limb was flaccid. The biceps and triceps tendon reflexes were prompt. They were a little prompter on the right probably because there was less atrophy on

that side. Muscles of the arm and shoulder, including the trapezius, were greatly wasted on the left; much more so than on the right.

The tongue had a marked fibrillary tremor on both sides and was wasted bilaterally. The masseters were normal. The soft palate was equally innervated.

The pulse had been as high as 138, but it was 120 for the last day or two.

The left lower limb was completely paralyzed with the exception of slight flexion in the toes. The left knee reflex was prompt and ankle clonus was distinct. The right Achilles' reflex was exaggerated, with ankle clonus. The right knee reflex was exaggerated. She had distinct power in the right lower limb.

Sensations of pain, heat and cold were distinctly impaired though not lost over the whole right side, trunk and lower limb; tactile sensation was fairly well preserved. The seventh and eighth nerves were not involved.

Examination suggested a tumor high in the cervical cord on the left side close to the medulla oblongata. The dissociation of sensation was of the cord type and was best explained by a lesion of the left anterolateral column at the highest cervical segment, even involving the medulla oblongata. It involved both hypoglossal and pneumogastric nerves.

There was no sympathetic paralysis of the eye. The left side of the diaphragm was paralyzed. Syringomyelia was possible but from the history did not seem to be the more probable lesion.

Operation.—On Nov. 17, 1921, a partial excision of the tumor was performed; also exploration of the upper cervical spine and region of the medulla.

Before the operation, the patient's condition was critical. She had total loss of function of the accessory respiratory muscles; half of the diaphragm was paralyzed, the other half functioning weakly. She was cyanosed and had had two attacks of respiratory collapse on the journey to the hospital.

Ether seemed to be contraindicated. Before the patient was placed on the table, face down, nitrous oxid was started, giving as much oxygen as possible. Should the nitrous oxid anesthesia not prove practicable, chloroform was to be substituted. The anesthesia worked out most satisfactorily, the head being held constantly in the hands of a nurse who could change the position as directed.

Spinous processes and laminae of the first, second and third cervical vertebrae were removed, with the posterior rim of the foramen magnum and the adjacent occipital bone for a distance of about 2.5 cm. As soon as the dural flaps were reflected a firm tumor of considerable dimensions was found, partly below and partly above the foramen magnum. The cord was well displaced to the right. The tumor occupied a left lateral position, and at the level of the foramen magnum there was a sharp indentation of the cord. Little by little the adhesions were freed, first around the lower pole, then working up on either side, and finally on the posterior aspect. The adhesions were so firm and the depth of the tumor such that it was impossible to remove it whole. The lower third was excised first, without difficulty. Another horizontal section was made about two thirds of the distance from the pole, and this second segment was removed without difficulty. While proceeding with the removal of the third section, respiratory failure occurred to which the patient succumbed. It was thought that perhaps by the use of the intratracheal tube the patient might be revived, but after artificial respiration was practiced for a few moments the circulation failed.

The tumor had the macroscopic appearance of a fibroma, but it was much more firm in its attachment to the surrounding tissue than is usual in tumors

of the spinal cord. Had it been as readily removed as the majority of these tumors, there would have been no difficulty in its excision. The method of exposure was well planned, and no time was lost in the detection of the growth. There seemed to be no other way of removing the tumor than segmentally, and the operation could not have been modified except perhaps to have performed it in two stages, rather than one.

Pathologic Diagnosis: Endothelioma.

CASE 2.—*History.*—T. J. S., aged 29 years, referred to the neurosurgical service of the University Hospital, Feb. 17, 1921, by Dr. Alfred Stengel, in September, 1920, while engaged in heavy work, noticed a lancinating pain posteriorly on the right side of the neck, extending down to the region of the shoulder. The pain was sharp and was aggravated on movement of the arm or neck or on being jolted as in an automobile. This "knife-like" pain persisted, at times lessening in intensity, but did not disappear. During the early part of 1921 it grew worse, and he was forced to give up work. Since then he has not been able to sleep comfortably because of the painful throbbing in the right shoulder.

In February, 1921, his ankles suddenly swelled, and he developed pain in both legs from his feet to a few inches above the knees. From the point of origin in the neck the pain extended down to the elbow, lower forearm and hand. The pains usually came on at night, as a dull ache, and were relieved by rubbing and by heat. The right hand was numb as well as painful and not fully under voluntary control.

He had had two teeth removed for abscesses, one five years before and one in October, 1920, without relief. There was no loss of weight.

Examination.—The patient held his head and neck stiffly because of pain in the right side of the neck. The muscles on the right side of the neck were rigid and painful on pressure. There was no limitation of movement of the spine. There was some atrophy of the muscles above the spine of the right scapula. Motion of the right shoulder was not free and easy. Motion of other joints was normal.

Feb. 24, 1921: Roentgen-ray Report: Cervical and upper dorsal vertebrae and shoulder were normal.

March 10, 1921: Examination by Dr. Kern: Left Arm: No atrophy; strength fair; grip of hand 95; biceps and triceps reflexes prompt; normal diadokokinesis; no dysmetria. Right Arm: Evident wasting, most marked about the shoulder girdle, supraspinatus and infraspinatus especially; slightly "winged scapula." The deltoid and biceps were wasted; grip 25. The lower extremities were normal. Sense of position, vibratory sense and stereognosis were normal.

The patient complained of subjective sensory disturbances in the legs, particularly the right; the right thigh felt cold. There was no sensory blunting to hot and cold water, pain and light touch. He said that pin prick felt sharper throughout the right side. There was hyperesthesia on both soles extending up over the dorsum of the foot to the malleolar level.

May 7, 1921: Examination by Dr. Spiller: The left side of the diaphragm appeared to move more than the right. The right pupil was a trifle smaller than the left. This had been repeatedly observed and is suggestive of transitory sympathetic paresis. Tactile and pain sensations were acute on the right side of the neck and in the right upper limb, but the man winced more from prick on the right side of the neck than he did from prick on the left as though he had slight hyperalgesia in the distribution of the third and fourth cervical nerves.

Atrophy of the right supraspinatus and infraspinatus muscles was marked; it was less advanced in the muscles about the right shoulder. Fibrillary tremors were pronounced in the right triceps, biceps and deltoid. The right biceps reflex was practically absent. Tapping the biceps tendon produced a paradoxical reflex; i. e., pronation of the forearm at the elbow, which indicates that the irritation produced causes a reflex below the fifth cervical, and that the fifth cervical segment is incapable of responding to reflex action. The right triceps reflex was exaggerated, perhaps a little more than the left. This would indicate that the sixth cervical segment on the right side was reflexly active. The left biceps tendon reflex was a little diminished; the left triceps reflex was a little exaggerated. The right lower limb was a little spastic in walking. Patellar and Achilles' tendon reflexes were markedly exaggerated, nearly equally so. Patellar clonus was present on either side, distinctly more pronounced on the right. Ankle clonus was present on the right side only. The Babinski reflex was uncertain.

Tactile sensation was entirely normal in both lower limbs. Pin prick was not felt in the entire left lower limb and was greatly impaired over the left side of the trunk, with no sharply defined border. Heat and cold sensations were greatly impaired, if not lost, in the entire left lower limb and probably somewhat affected in the left side of the trunk.

Summary.—There was a complex commencing with pain in the right side of the neck, extending to the shoulder. Transitory sympathetic paresis of eye was present on the right side. There were atrophy of the muscles and fibrillary tremors in the fifth and sixth cervical distribution. The biceps reflex was absent on the right side. There was anesthesia for temperature and pain, not for touch, in the left lower limb. There were slight weakness and spasticity of the right lower limb, exaggeration of the tendon reflexes and diminution of diaphragmatic action on the right side.

Localization.—There was a lesion at the fifth, possibly at the fourth, not involving the sixth, cervical segment, extramedullary, on the right side of the cord, beginning probably from the posterior roots and increasing in size. There was probably, therefore, a tumor, likely to be an endothelioma or a fibroma.

Operation and Course.—June 4, 1921, a laminectomy was performed. Ether anesthesia was used, endopharyngeal method. The third, fourth and fifth spinous processes and laminae were removed. The tumor was found on the right side of the cord, half above and half below the point of origin of the posterior root of the fourth cervical segment. This passed over the middle of the tumor (Fig. 13). The tumor extended into the intervertebral foramen, following the course of the root at least 1 cm. beyond the spinal canal. The removal here was attended with some difficulty. Its presence within the foramen would suggest this as its point of origin. The fourth sensory root was sacrificed at the operation, and the anterior root necessarily somewhat traumatized. At the conclusion of the operation the field was entirely dry. The dura was closed with continuous silk sutures, and the remainder of the wound with tier sutures. The naked eye appearance of the tumor was that of an endothelioma.

Pathologic Diagnosis: Fibroma.

The postoperative convalescence was uneventful except for transitory weakness of both arms. The man was discharged from the hospital twenty-two days after the operation and later resumed his occupation.

Case 3.—*History.*—Mrs. H. T. S., aged 33 years, referred to the neurosurgical service, University Hospital, by Dr. Charles K. Mills, Feb. 22, 1910. The

patient had been married eight years, had two children, and had always enjoyed the best of health, except for occasional fainting spells, the last of which occurred eight years ago. Two years previous to admission, pain began in the back of the neck and left shoulder which somewhat resembled rheumatism and was treated as such. Later the pain, which was sharp and shooting, came at intervals lasting from five to twenty minutes, and gradually extended down the arm. There was also a sensation of numbness in the left arm, leg and foot, and later decided weakness on the left side (Fig. 14).

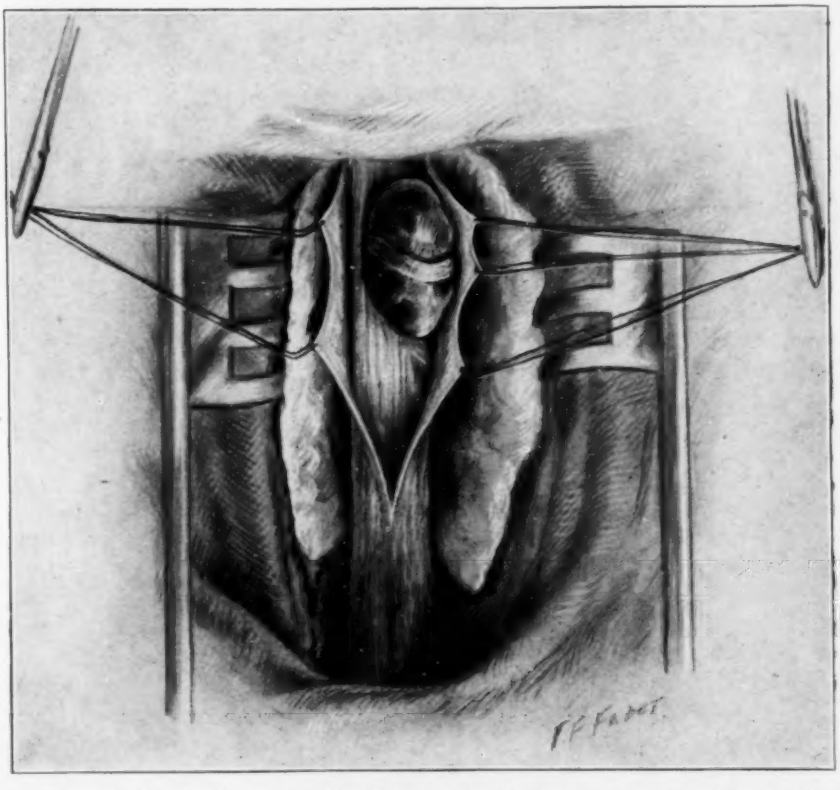

Fig. 13.—Illustration reproduced from drawing made at operation to show relation of the posterior root of the fourth cervical segment to the tumor.

Examination.—Sensation for touch, pain and temperature was normal. There was moderate, inconstant impairment of the sense of position of the left hand. The grip of the left hand was impaired. Amplitude of motion in the left extremities was somewhat restricted due to muscular weakness. The scapulo-humeral reflex was slightly greater on the right, as were also the coracobrachial and the biceps tendon reflexes. In the lower extremities the reflexes were all increased, those of the left side being greater. A Babinski reflex was present on the left only. There was no ankle clonus. Tonicity of the left lower limb was somewhat increased, of the others normal. Electrical reactions in the left arm were normal.

The roentgenogram showed a shadow to the outer side of the fourth and fifth cervical vertebrae on the left. The mass was small and lay in such a position that it might readily press on the posterior roots. The left halves of the fourth, fifth and sixth vertebral bodies seemed a little denser than did the right.

Operation and Course.—Laminectomy was performed, Feb. 25, 1910. A semilunar skin flap was reflected and an incision made to the left of the median line.

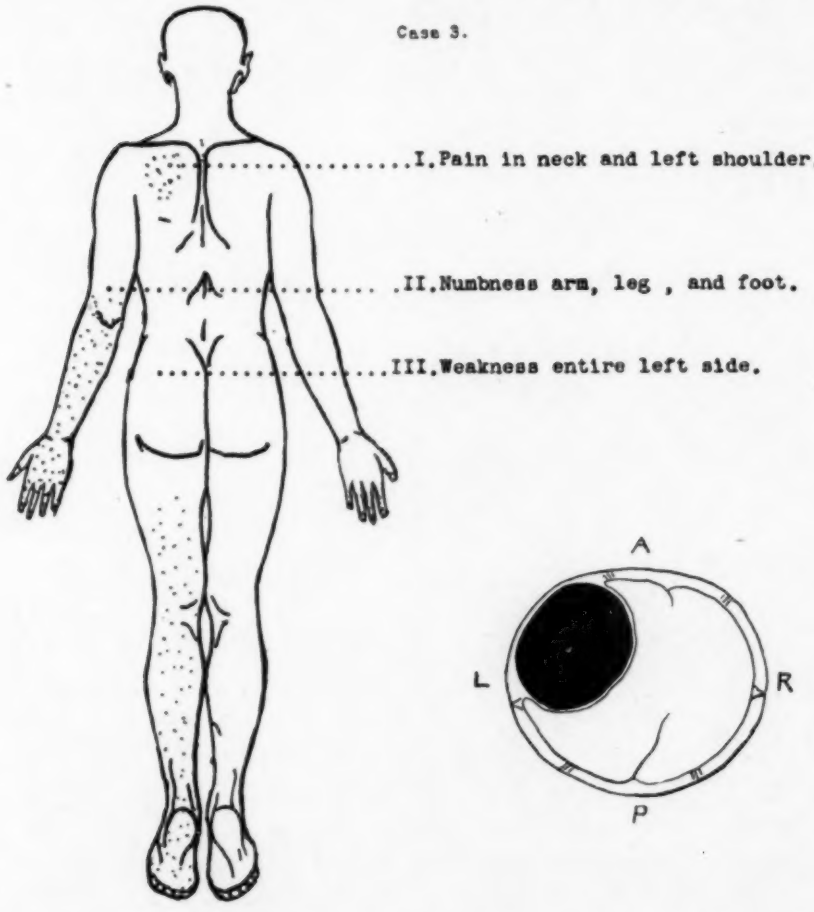

Fig. 14.—Chronologic sequence of symptoms with diagram, showing the relation of the tumor to the cord.

The spinous processes of the fourth, fifth and sixth cervical vertebrae, the laminae of the fifth and a portion of the sixth were removed. There was little hemorrhage. The dura was opened, exposing a tumor about the size of a chestnut, located a little above the level of the fifth cervical vertebra. The sixth posterior root ran over the mass, and it was impossible to say whether the anterior root ran through it. The fifth posterior root was in contact with

the upper end of the mass, which was very friable. In removing it there was marked twitching of the left shoulder. Pathologic Report: Endothelioma.

1918—The patient made an uneventful recovery, and eight years after the operation is practically well. There are no muscular atrophies. The tonicity of the left arm is greatly increased and the reflexes exaggerated. The patient reports that the use of this arm has returned for all practical purposes, cold alone decreasing the freedom of activity. The grip in the left hand is not so strong as in the right. There is no pain in the left shoulder nor on that side of the body below the arm. However, an occasional pain is felt in the region of the scar on the neck, and severe radiating pains, occurring at intervals of two weeks to a month, and being at present of less severity, involve the left arm and forearm and extend into the fingers. Heat and cold sensations are about normal in the arm, forearm and hand, and the patient is able to recognize objects in the left hand. There is still, however, some abnormal sensation in the left forefingers, described as a tight and distended feeling. In the left lower extremity all reflexes are greatly exaggerated and all sensations intensified, while in the right lower extremity all sensations are subnormal and the reflexes decreased. The sphincters are normal. Ankle clonus and the Babinski sign are present and the patellar reflex exaggerated on the left side. The gait is normal, with the exception of a slight spasticity in cold weather.

Case 4.—*History.*—E. M., aged 64 years, referred to the neurosurgical service of the University Hospital, Feb. 21, 1916, by Dr. C. E. Riggs, in November, 1914, noticed a dull aching pain in the right shoulder region just below the clavicle, extending out and down as far as the insertion of the deltoid muscle. Pain was increased for the time by coughing and sneezing, and radiated posteriorly. This condition continued until, July, 1915, when she noticed numbness in the fingers of the right hand. This gradually extended to the wrist. She could handle a knife and fork until August, 1915, but there was progressing disability of the right hand. From this time on the hand has been almost helpless, and the left hand has become weak. The left upper limb, however, is moved involuntarily with ease.

August, 1915, about a month after the fingers were affected, numbness and tingling were first noticed in the toes of the right foot. Following this she complained of awkwardness of the right lower limb, frequently stubbing the toe in walking. October, 1915, she complained of paresthesia in the left hand and arm, but it never progressed as far as it has in the right upper limb. In October she also complained of a girdle sensation. All of these conditions have been growing worse. Her right ankle was weak and frequently turned. She was markedly constipated and could not void while in bed.

Examination.—The patient was a fairly well nourished, white adult female, with a moderate amount of fat. Her skin was sallow. Results of general examination were negative. There was slight tenderness on pressure over the fourth and fifth cervical spines. This tenderness was aggravated by forcibly flexing the neck.

Lumbar puncture: Pressure 6 mm. of mercury. The Wassermann test of the spinal fluid was negative. The globulin test was negative; lymphocytes, 12 per centimeter. A roentgenogram of the cervical spine was negative.

Notes by Dr. Spiller: Heat and cold sensations were probably normal in all limbs though the patient made mistakes. The recognition of heat, cold and pain was prompt on either side of the face. Sensations of pain were normal in the lower limbs and also in the right side of the neck. Tactile sensation was normal in all extremities with the exception of an area on each shoulder anteriorly just below the clavicle where there was impaired pain and tactile

sensation, in the distribution of the fourth cervical roots. Sense of position and of passive movement was apparently disturbed in both hands and much impaired in the right toes. The patient tired quickly and attention flagged.

There was only a little movement in the right fingers, some reflex at the right elbow and some elevation of the right shoulder. The lower limbs were somewhat spastic. There was some power in the right lower limb at the hip and knee but none lower. The left lower limb had fair power.

The biceps and triceps reflexes were exaggerated in each upper limb, patellar reflexes were also exaggerated with abortive patellar clonus on the right. The Oppenheim and Babinski reflexes were distinct on the right; the Babinski sign was uncertain on the left; the Oppenheim sign was not obtained. The reflex of defense was marked on the right; there was an indication of it on the left.

Operation and Course.—On Feb. 26, 1916, a laminectomy was performed. A tumor was found at the level of the fourth cervical segment and removed. The spinous processes of the second, third, fourth and fifth cervical vertebrae and the laminae of the third, fourth, fifth and part of the second were removed. There was no visible pulsation. The dura was incised, and on pricking the arachnoid, the cerebrospinal fluid spurted out 1 or 2 inches and about an ounce escaped. The tumor was found at the level of the third lamina on the right side of the cord, covered by a membrane which, when divided, showed more sharply the differentiation between the cord and the tumor. The tumor, encapsulated, arose from the dura on the right anterolateral aspect of the spinal canal to which it was firmly adherent. Enucleation and elevation from its bed were conducted without traumatizing the cord. Neither anterior nor posterior roots were sacrificed with the exception of the third posterior root. This root passed from its point of exit from the dural sac over the superior aspect of the tumor where its identity was lost; apparently it had no connection with the cord. At the beginning of the operation the blood pressure was 120; it rose in a few minutes to 145 and dropped later to 105; at the conclusion of the operation it was 120, the pulse 134. The wound was closed with tier sutures. Pathologic Diagnosis: Endothelioma.

Convalescence was uneventful. Shortly after the operation the patient began to regain power in the right upper and lower limbs and sensation slowly returned. On discharge from the hospital the grip of the right hand was moderate. The patient could move the right arm quite freely, place her hand on her head and move her fingers in all directions. The areas of anesthesia just above the clavicles on either side had disappeared. There were no disturbances of sensation except pain in the left leg and foot. Strength had increased greatly in the legs; there was no spasticity, and no ankle clonus or Babinski sign. The biceps and triceps reflexes were prompt, but not nearly so prompt as at the time of admission.

The general improvement throughout was most striking. The readiness with which the patient answered the tests for sensation was quite a contrast to the slow, doubtful and often confused way in which she responded before operation. She still complained of slight tightness around the waist.

Case 5.[2]—*History.*—H. B., aged 18 years, referred to the neurosurgical service of the University Hospital by Dr. William G. Spiller, Oct. 7, 1919, about nine months ago had severe pain in both upper extremities, coming on rather suddenly and rapidly increasing in intensity. It was constant with severe paroxysms lasting about half an hour. She obtained greatest relief by standing with her back against a warm radiator. This condition lasted about three months

2. This case was referred to in Am. J. Med. Sc., March, 1920.

with varying severity. There was no paralysis at that time. Then followed a period of about three months in which she was very weak, walked with difficulty and stumbled. While being treated by an osteopath she developed complete paraplegia. At this time Dr. Schwartz found markedly increased reflexes of the lower extremities, ankle clonus and the Babinski sign on both sides. On manipulation she became very spastic. Sensation of heat and cold

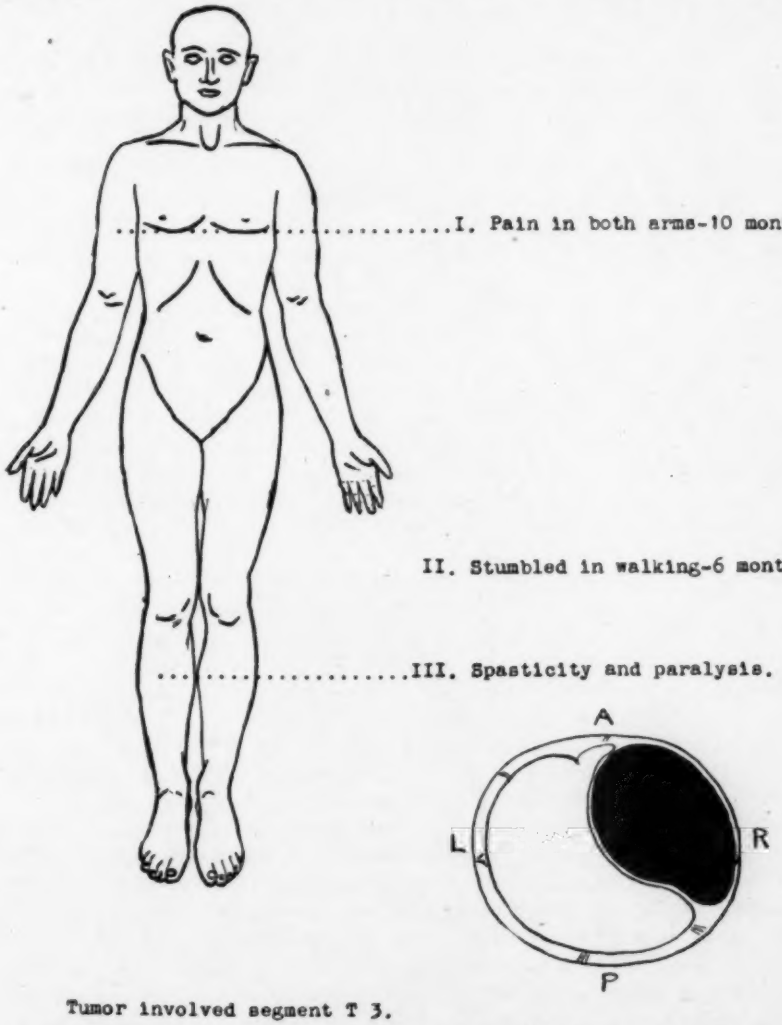

Fig. 15.—Chronologic sequence of symptoms with diagram, showing relation of tumor to the cord.

was absent in the region of the sixth thoracic spine. Pain and tactile sensations were diminished in the same area and slow of recognition. There was difficulty in starting urination but she voided freely; she was never catheterized; there was no incontinence. She was constipated; there was no bowel incontinence. The pupillary reflexes were normal. There had been very little change in the last three months except that she became somewhat less spastic (Fig. 15).

Examination.—The patient was a small, poorly developed, and somewhat undernourished white female. There was a small decubitus in the sacral region covered by a scab. Mentally, she was keenly alert. She lay in bed bolstered up with pillows, with legs partially flexed and drawn up. She moved the upper extremities readily. She could not stand or walk. Results of examination of head, cranial nerves, neck and thorax were negative.

Both upper extremities were rather small and rather weak; the thenar and hypothenar eminences were thin and flattened; more distinctly on the left; there was no atrophy of the forearms or arms. In the supraspinous and infraspinous regions on the left there was some wasting, also of the left deltoid. Flexion of the little finger appeared to be weaker on the left. There were no palsies of any part. The fingers of the left hand were held in partial flexion of the second and third phalanges and extension of the first. Sensation in the upper limbs was normal. There was no dysmetria, adiadokokinesis, astereognosis, or tremor. The biceps reflex was normal (or diminished). The triceps reflex was normal on the right, diminished on the left. The wrist reflex was normal.

In the lower extremities there was no voluntary motion. The legs were spastic and manipulation threw the whole extremity into partial clonus which seemed painful. Manipulation of any part of the body might bring on this spastic condition. Asked if she had pain she answered, "Yes, sometimes, but not always." She said that the pain was not in the legs, but in the shoulders (in the scapular region), more on the left. There was no atrophy or tremor of the lower extremities. Pain and temperature senses were greatly diminished or lost in both lower extremities and extending up the trunk to about the fourth or fifth interspaces. Touch sense was absent over the same area, but deep pressure was felt. There was no vibratory perception when the tuning fork was placed over the malleoli or on the tibia. Sense of position was lost in the toes. There was a very small red spot (hard) on the right upper thigh. The knee reflexes were exaggerated. Even a light tap often produced right or left clonus. The Achilles' reflexes were exaggerated. Tapping of the tendon produced ankle clonus on each side. There was a distinct ankle clonus when tested in the usual manner, greater on the left than on the right. There was a marked Babinski sign, the same on both sides.

Operation and Course.—On Oct. 18, 1919, a laminectomy was performed and an endothelioma was removed. The tumor was believed to be at the level of the third thoracic segment which is opposite the tip of the spinous process of the seventh cervical vertebra. This was identified the day previously by the roentgen ray. With this point approximately as the center of the incision, the laminae of the first thoracic, and sixth and seventh cervical were removed. There was a fusiform enlargement of the contents of the canal as seen by the bulging of the dura. The dura was opened, and the bluish outline of the tumor was seen presenting at the anterolateral aspect of the cord at the level suspected. After incising the pia definition of the tumor became more sharp, and by gentle retraction of the cord it was bluntly dissected from its attachment. The posterior seventh root passed about over the middle of the tumor and had been retracted while the growth was being removed. After the tumor was taken out, there appeared to be a defect in the dura at the point of exit of the anterior division of the eighth cervical and first thoracic. This led to a space anterior to the canal which seemed to be filled with soft granulation tissue or possibly tumor. Apparently it was removed intact. It was thought wise to sacrifice the anterior root at this point as it probably was involved by the

tumor growth. Hemorrhage was controlled, and the wound closed in the usual way. The patient's condition toward the close of the operation was rather serious, although there had been little loss of blood and relatively little trauma. The patient was given 1 pint of saline solution intravenously with appropriate stimulation.

Postoperative Note: There was transitory incontinence of urine and feces. The left palpebral fissure was distinctly narrower on the right, and the right pupil was smaller. Sweating was marked on the right side of the face at times. Six days after operation the sense of position in the toes and of deep pressure in both legs had returned. Three weeks after operation motion was returning to the ankle joints, and the sensory disturbances were rapidly subsiding. Within five months there was almost complete functional recovery of the lower limbs, and later the patient walked five miles.

Case 6.—*History.*—Mrs. W. F. G., aged 60 years, referred to the neurosurgical service of the University Hospital, Feb. 3, 1920, by Dr. William G. Spiller, in March, 1918, first complained of pain between the shoulders, dull in character and observed especially on moving the arms. Later she observed a sleepy feeling in the tips of the right fingers and still later the pain extended to the right arm and elbow. In September, 1919, she complained of weakness and numbness in the right leg. There was loss of temperature sensation in this limb, but touch sensation was preserved.

In November, 1919, she felt as if there were a band about her abdomen; in December, 1919, the right lower limb grew stiffer and jerked, especially when lying in bed. She could not flex the little finger of the right hand, and noticed a stinging sensation in the ulnar side of the right upper limb. The last few days she has had similar sensations in the left hand. She can walk a little with the aid of a cane.

Examination.—The right pupil was slightly smaller than the left, and the right palpebral fissure was smaller. Movement of the head on the trunk was restricted. The left arm and hand had fair power, not so good in the triceps muscle. There was no atrophy. The grip of the right hand was very weak; the right thenar and hypothenar eminences were wasted and the little finger was especially weak. The biceps reflex was normal. Striking either triceps tendon produced no contraction of the triceps muscle, but contraction of the biceps and supinator longus—a paradoxical reflex. The right lower limb was very spastic, the left was normal. Voluntary movements of the right lower limb were restricted, but not of the left. There was no atrophy. The patellar and Achilles' reflexes were much exaggerated, more so on the right. The Babinski sign was present on the right, not on the left.

Sense of position was lost in the right little finger and impaired in the right ring finger and toes of the right foot. Vibratory sense was lost in the right and impaired in the left lower limb. Sensation to touch and pressure was normal everywhere except in the right little finger and ring finger. Touch, pain, heat and cold sensations were distinctly diminished on the inner side of the right arm, forearm and hand. Temperature and pain sensations were lost in the left lower limb to just above the knee and impaired from there up to the level of the third interspace in front and the third thoracic vertebra in the left side of the body. Roentgen-ray examination of the cervical spine was negative.

Operation and Course.—On Feb. 12, 1920, a laminectomy was performed. The spinous processes and laminae of the fifth, sixth and seventh cervical and the first thoracic were removed. On opening the dura a tumor was found

anterolateral in position, having displaced the cord to the left and rotating it on its axis so that the posterior roots appeared to come off on the portion of the cord immediately presenting in the wound. The posterior roots of the eighth cervical and first and second thoracic stretched across the tumor. These roots were all spared but the upper one which had to be sacrificed (Fig. 16). The tumor was firmly adherent to, infiltrated, and had penetrated, the dura

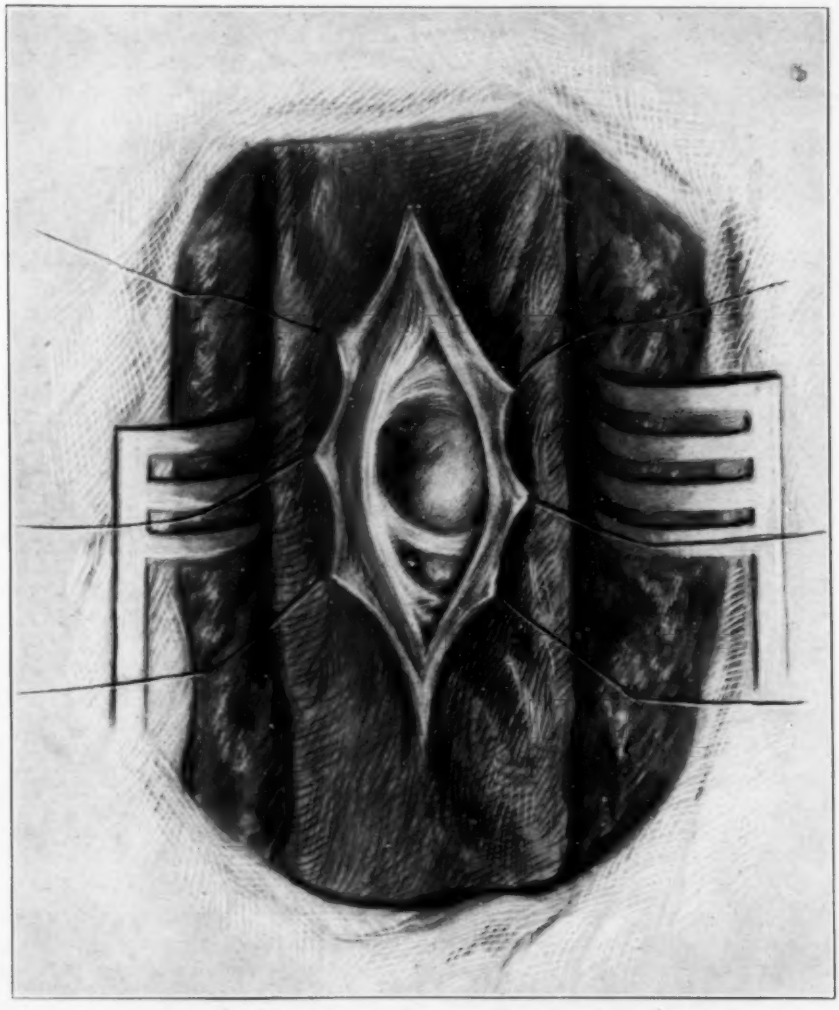

Fig. 16.—Appearance of tumor at operation.

in the lateral aspect of the canal on a level with the anterior root of the first thoracic segment. That portion which had infiltrated the lateral wall of the canal became detached and was removed separately. There was also sharp bleeding from the point of attachment which was controlled with two small muscle grafts. The space left by the removal of the growth appeared to be about two thirds of the diameter of the canal, the cord occupying the remain-

ing third. Hemostasis was perfect at the conclusion of the operation. The dural wound was closed with a continuous silk suture, the muscle and facial planes with tier catgut sutures. Tubular drainage was employed.

Postoperative Notes: The patient made an uneventful recovery, and on Nov. 25, 1921, a year and nine months after the operation, she had some pain in the right upper limb from the elbow to the little and ring fingers, some twitching occasionally in the right foot, occasionally some involuntary contraction in the right hand, and slight diminution of touch and pain sense in the ulnar distribution of the right hand. She was able to walk without difficulty and to use the right upper limb freely.

CASE 7.—*History.*—W. S. D., aged 44 years, referred to the neurosurgical service of the University Hospital by Dr. James M. Anders and Dr. Charles K. Mills, about five years ago first complained of pain in the lower sternal region. At first the pain lasted only a few seconds and was brought on by movements such as stooping. Later the patient noticed a sense of numbness in the right leg and foot and right side of the scrotum and in the second and third toes of the left foot. Two years before the patient began to complain of weakness in the left leg. Now his leg becomes stiff if he keeps it in one position for any length of time.

Examination.—The patient showed great unsteadiness on his feet with his eyes closed. This apparently was due to weakness of the legs, especially the left. There was no change in pupillary reflexes or ocular movement. Movements, sensation, reflexes, etc., were normal in the upper extremities. There was marked impairment of power in the left lower extremity, somewhat more marked proximally than distally. All parts of the limb were, however, more or less affected. He could not throw the left leg over the right, nor the right over the left. He could abduct, adduct and dorsal flex the foot, but with feeble movements. He could elevate the left heel somewhat feebly. He had general impairment of power in the right lower extremity, but less marked than in the left. Ankle and knee reflexes were greatly exaggerated on both sides. There was foot clonus on both sides, more persistent on the left. There was a Babinski sign on both sides. Abdominal and cremasteric reflexes were absent.

Examination for sensation was somewhat indecisive, but it was found that there was no loss of the sense of position or of passive movements in either lower extremity. On the right, sense of touch, pain, heat and cold were retained, but they were diminished, comparing the right with the left. The upper limit of the impaired sensations was 2 or 3 inches (5.08 to 7.62 cm.) above the umbilicus, close to the position where he said he had had pain five years before.

Operation and Course.—On June 1, 1919, a laminectomy was performed under ether anesthesia. The spinous processes and laminae of the upper thoracic spine were removed sufficiently to expose the third, fourth and fifth thoracic segments. The tumor was situated on the left side of the cord and had the gross appearances of the more common extramedullary endotheliomas. It was removed intact without difficulty and without traumatizing the cord. The hemorrhage was checked and the wound closed.

Postoperative Notes: Following the operation the patient gradually developed signs of a complete transverse lesion, so that a week after the operation there was complete paraplegia, loss of sensation and of reflexes, with an extensive decubitus and retention of urine.

Eleven months after operation there had been no return of sensory or motor function. With the hope that possibly a recurrent growth might be found, an exploratory operation was performed.

May 4, 1920, a laminectomy was again performed under ether anesthesia, endopharyngeal method. The incision followed the line of the original incision. One spinous process and lamina above the original laminectomy were removed, and from this point down the posterior aspect of the dura was isolated and eventually opened. The dura and the arachnoid were moderately adherent, but the lines of demarcation between these and the cord were readily recognized and separation was made with a sharp knife. The site previously occupied

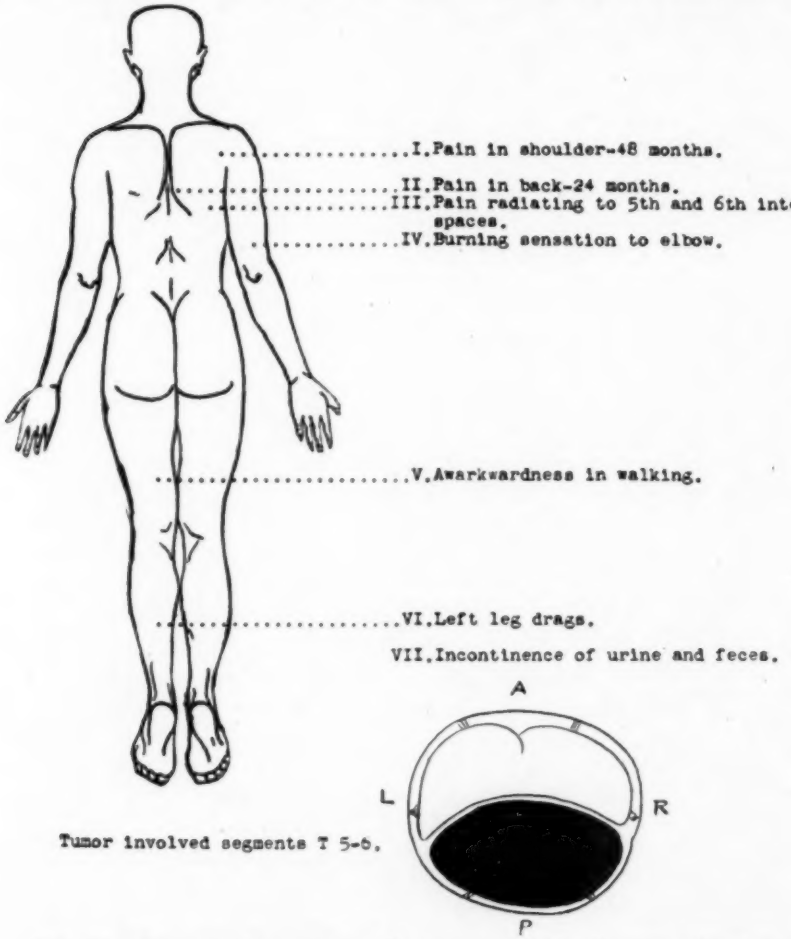

Fig. 17.—Chronologic sequence of symptoms with diagram, showing relation of the tumor to the cord.

by the tumor was readily recognized as a cavity to the side of which were found remnants of cord tissue which had evidently gone on to practically complete degeneration. There was no evidence of a recurrent growth or of any pressure or constriction of the cord by fibrous tissue such as might have formed from the organization of a blood clot.

CASE 8.—*History.*—F. S. P., aged 35 years, referred to the neurosurgical service of the University Hospital by Dr. Charles K. Mills, Nov. 10, 1918, four

years before complained of pain under the right shoulder. Two years before she began to have a sharp pain between the shoulder blades. This continued and resembled a throbbing toothache. Then she noted a sharp pain radiating from this region forward along the fifth and sixth ribs to the right, and at times a burning sensation on the posterior and anterior surface of the upper part of the right arm to the elbow. The pains were not constant but were aggravated by motion. She wore a plaster jacket for four weeks. After that she noted that the lower limbs were stiff; for this she received massage but was not benefited. An osteopath did not relieve the pain in the back, but she became less awkward in walking. At present she has a dull aching pain between the shoulder blades, occasionally radiating to the right ribs, fifth and sixth, with an occasional burning sensation along the dorsum of the upper part of the right arm. She says that she can walk only with support as she feels uncertain on her feet. Her lower limbs are stiff, but without pain and the left one drags. She has some incontinence of feces and urine (Fig. 17).

Examination.—The cranial nerves were normal but the right pupil was slightly larger and a little perspiration was almost constant above the right orbit. The patient said this was present even on a cold day.

There was considerable swaying on standing, increased by closing the eyes. The left leg especially was weak and tended to drag. The gait was somewhat uncertain and ataxic. The left leg was more spastic than the right. The power in her legs was more impaired since September, 1919. The upper extremities showed no weakness, atrophy or tremors; stereognosis was good, rapid rotary motions well done; there was no ataxia. There was good muscular power in each. There were no sensory changes. Biceps and triceps reflexes were normal. Both lower extremities were spastic and weak, especially the left. There was no atrophy or palsy of any part and no tremor. The heel to knee test was well done on each side.

Sensation to touch was good in all parts, but more pressure was required in the legs, and there was slight impairment in the lower part of the abdomen. There was no impairment above the seventh interspace. Pain sense was everywhere present but was more impaired than the sense of touch; it was normal above the seventh interspace (more impaired in the right leg?). Temperature sense was markedly impaired in the legs, especially on the right, and there was distinct impairment up to about the sixth and seventh interspace. The sense of position was normal in the feet.

The patellar reflexes were exaggerated and equal; the Achilles reflexes were overprompt and equal. The Babinski sign was present. There was also a marked reflex of defense. Ankle clonus was slight on the left. (Two days before it was persistent on each side.)

Lumbar Puncture: Pressure, 11 mm. of mercury. Five cubic centimeters of fluid were removed. The fluid was clear, yellowish; no coagulum. The cell count was 4 per cubic millimeter; there was marked increase of globulin; the Wassermann test was negative.

Roentgen-Ray Examination: The thoracic vertebrae showed no abnormalitities.

Operation and Course.—On Nov. 11, 1917, a laminectomy was performed. The landmarks on the skin were opposite the spinous processes of the first and fourth thoracic. The incision extended one spinous process above and below these. The spinous processes and laminae of the first, second, third and fourth vertebrae were removed and the dura opened; the tumor immediately presented itself, occupying the posterior aspect of the canal in the lower third

of the opening. The tumor was removed intact, sacrificing only what was identified as the sixth thoracic root, from which the tumor probably took its origin. The stump of the root was ligated to control hemorrhage. The tumor really extended one lamina below the opening, but as soon as its upper half was freed, it popped out like a grape from its skin. On its removal the tumor measured 2 cm. at the widest diameter and 5 cm. in length. The wound was closed with tier sutures and tubular drainage was employed.

Postoperative Notes: There was some increase in voluntary power of the left lower extremity. The right lower extremity showed no change in power. There was considerable impairment of the sense of position, especially in the right foot. Sensory disturbance was the same as at preoperative examination, except less in degree. The recognition of heat and cold, touch and pain was much more acute on the trunk below the sixth interspace than at the preoperative examination. The patient felt considerably better than she had been feeling. Power was returning in the left lower extremity to a considerable degree. She was discharged from the hospital three weeks after operation, and one year later Dr. Mills reported that there were no signs of recurrence.

Case 9.—*History.*—R. C. H., aged 24, referred to the neurosurgical service of the University Hospital by Dr. Alfred Stengel, Dec. 14, 1921, was well until 1920, when her back was hurt in an automobile accident. She later fell while skating and was again in an accident the following year. In November, 1921, she had pains in the back. Following the menstrual period on Nov. 16, 1921, she had occipital headache and was almost delirious. From this time on she had difficulty in walking. Numbness developed from her breast line down. Paresthesias began six months before in the arms, breasts and axillae. The patient was admitted to Dr. Stengel's service on Dec. 14, 1921. She was seen by Dr. Spiller on Jan. 1, 1922, and the condition was thought to be organic. She was again seen by Dr. Spiller on Feb. 28, 1922, and a diagnosis of cord tumor was made and operation requested.

Examination.—The patient was an athletic and well developed young woman. She was very intelligent. There were no gross abnormalities about the head. The eyes were normal; the left pupil slightly larger than the right, the left eyeball slightly more prominent. The irides reacted normally to light and in convergence. All other cranial nerves were normal.

From the fourth intercostal space downward the touch, pain, temperature and vibration sensations were lost except in the soles of the feet. In each axilla and extending down the inner aspect of the arm was an area that had no sensory function.

There was loss of sense of position in the toes and a strong reaction of defense in the feet. Spasticity of the lower limbs was marked. Ankle and patellar clonus were persistent. The Babinski sign was present on both sides. Patellar and Achilles' reflexes were exaggerated and tended to go into clonus. She had some difficulty in starting the functions of the bladder and bowels.

Operation and Course.—On March 3, 1922, a laminectomy was performed. Spinous processes and laminae of the seventh cervical and of the first, second and third thoracic were removed; the tumor was found beginning just below the level of the fourth thoracic segment, or what corresponded to that according to our roentgen-ray identification. The tumor was 9 by 3 mm., and covered the whole posterior surface of the cord. It could be exposed only by removing the laminae as far as the articulations. On the left the tumor extended almost to the anterior aspect of the cord. It was entirely removed although tediously because of its width and length. To control bleeding

silver clips were used, before section of either side, which included the plexus and the veins over the cord. The tumor was entirely extradural.

CASE 10.—*History.*—P. E. S., aged 43 years, referred to the neurosurgical service of the University Hospital by Dr. William G. Spiller, July 3, 1918, a little over a year before felt a dull pain 2 inches (5.08 cm.) below the apex of the right scapula, which would come on after hours of rest, usually after midnight, disappearing shortly after the patient arose. Sitting in a chair, walking about the room, or a bath would relieve the pain. The pain grew gradually worse and for the last two months has been boring and radiating, sharp and lancinating. It radiates from the right side, 2 inches below the apex of the scapula, follows the intercostal nerve toward the costal margin and epigastrium, but never extends beyond the midline. There is no pain on the other side and no girdle sensation.

Shortly after the dull pain started in the side, a burning and dry sensation of both feet developed, beginning in the right one. There was no tingling or numbness at that time, but both developed later and extended gradually up to the level of the umbilicus. These were associated with a sense of constriction below the knees. At this time the gait became unsteady, and the patient began to sway from side to side in walking. For the last six weeks he has noticed a gradually increasing weakness of the limbs. His gait is spastic with muscles tense,, especially after resting. There is difficulty in starting the stream and after urination there is dribbling of urine. He is unable to control flatus.

Examination.—There were no headaches or dizziness. Vision, hearing, taste and smell were normal. The pupils were normal; there was no intra-ocular palsy.

There was no ataxia, weakness or tremors of the hands, and no paresthesias of the upper extremity. The grip of the left hand was considerably stronger; both hands showed good power. The biceps and triceps reflexes were normal.

The left patellar reflex was greatly exaggerated, the right more so. The Achilles reflex was also exaggerated, but less than the patellar. On striking the right Achilles tendon a slight clonus occurred. There was a doubtful Babinski sign on the right and left. Patellar clonus was present on the right, doubtful on the left. On heel to knee test there was a slight ataxia of the right leg. There was a slight impairment of sense of position in the right foot, none in the left

Touch sensation was acute. The patient said that touch felt different over the tibial region. There was loss of cold and heat sensations over the whole right lower limb and abdomen exactly to the level of the umbilicus and on the left side to 1 inch below this level. On the right side pain sensation was markedly impaired up to the inguinal region and diminished to the level of the umbilicus; on the left side to about an inch below this level. Sensation above the umbilicus was normal.

The Romberg sign was strongly positive on rising; after walking, normal. The gait was a little uncertain, the right lower limb being slightly spastic.

Notes by Dr. Spiller: Heat and cold were not distinguished on the right up to the umbilicus and on the left to 1 inch below the umbilicus. There was a fair but perhaps not entirely normal sensation of heat and cold around the anus and in a small strip down each thigh in the distribution of the second, third, fourth and fifth sacral nerves. The same localization of disturbance of sensation of pain was present. Over the abdomen, pain sensation was diminished, not lost, but it became acute on the right side and at the level of the umbilicus, and in the left side about an inch or more below the umbilicus. At

times the patient recognized the prick of a pin on the outer side of the leg below the knee and on the dorsum of each foot. Over the anterior surface of the thighs pain sensation was possibly more impaired than over the legs.

Operation and Course.—On Aug. 3, 1918, a laminectomy was performed under ether anesthesia, endopharyngeal method. The spinous processes of the ninth thoracic vertebra had been identified with the roentgen ray. The tumor was believed to be at the level of the ninth or tenth thoracic segment. An incision was made extending from the fourth to the ninth thoracic spinous process and before the spinous processes were removed a guide suture was introduced into the aponeurosis at the level of the spinous process of the sixth thoracic vertebra. The spinous processes of the fourth, fifth, sixth, seventh and eighth were then removed, and the corresponding laminae. When the dura was exposed, there was marked pulsation. On opening the dura an oval swelling of the cord was seen at the level of the eighth or ninth segment, probably just between them. This swelling was 2.5 to 3.5 cm. in length. It was thought at first that we were dealing with an intramedullary tumor, but on displacing the cord a little toward the left, a faint line of demarcation could be seen between the cord and the tumor on its anterior or slightly anterolateral aspect. This was covered with pia and arachnoid, and after these were removed the outlines of the tumor were readily recognized. It looked like an endothelioma and when removed measured 2.5 by 2 cm., being of the usual olive shape. The anterior root of the seventh segment crossed the posterior aspect of the tumor. The tumor itself did not seem to be in any closer relation with the eighth than with the ninth posterior root, nor to be attached to the roots but to the dura on the anterior aspect of the spinal canal. From this it was separated and when removed appeared to have a definite capsular covering. There was only one bleeding point where the tumor was attached. Bleeding was controlled with a muscle graft and the wound closed with tier sutures.

Postoperative Notes: One month after operation the patient was discharged. His convalescence was uninterrupted. He was without pain and his gait was constantly improving.

On July 23, the patient, who was a physician, wrote that he could walk straight and was working every day, operating.

Case 11.—*History.*—F. P., aged 52 years, referred to the neurosurgical service of the University Hospital, April 12, 1921, by Dr. A. M. Ornstein and Dr. William G. Spiller, entered the hospital for the first time in September, 1915, and left one month later. At that time she complained of a burning sensation in the epigastrium accompanied by vomiting. Five weeks previous to admission, except for occasional headache, she had been well. At this time she developed cramplike pains in the abdomen about the umbilicus, with a burning sensation in the epigastrium. She vomited persistently, neither the vomiting nor the pain, however, being related to the time of eating. Her appetite was poor, and she was constipated. She complained of shortness of breath on exertion, palpitation and a little swelling of the feet. She had lost 30 pounds (13.6 kg.).

On her second admission, two weeks later, she still complained of epigastric pain, worse at night and radiating toward the angle of the scapula. At this time she vomited every morning, still had some dyspnea on exertion with slight cough, but no expectoration. She still complained of swelling of the ankles as the day progressed. The patient again left the hospital.

Nothing was heard from her until her present admission. She now complains of weakness and epigastric pain. The patient says that about a year ago she felt a burning sensation all along her spine. She would get one of these attacks every week or so. It was not an actual pain but only a vague burning. About three weeks ago some medicine stopped this burning. She had always had slight pain in the epigastrium, a dull boring pain, not related

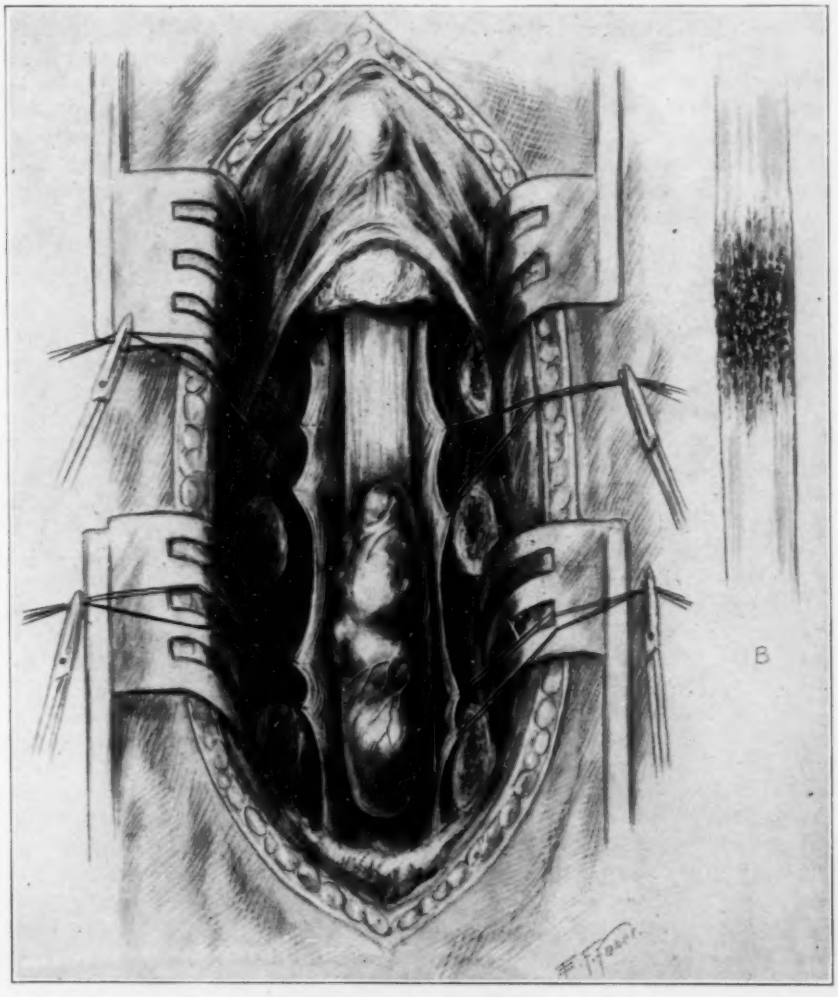

Fig. 18.—Tumor as seen at operation.

to or affected by meals. She had not vomited during the last five years; i. e., since she left the hospital. During the last three weeks, the epigastric pain had become steadily worse, with some radiation to the left, was worse at night, usually beginning about 10 p. m. and continuing all night, with relief toward morning. She was more comfortable during the day when moving about. Her bowels were constipated, sometimes for five or six days without

a movement. She was subject to severe headaches. She had lost about 15 pounds (6.8 kg.) lately. At the present time her appetite is poor; she does not sleep well and groans most of the time.

Examination.—There was some edema of the feet and ankles. Both legs were very spastic and were drawn up on the thighs.

Touch, temperature and pain sensations were lost over the lower extremities and up as high as 2 inches above the umbilicus; it was about equal on the two sides. Posteriorly, the border was at the level of the twelfth thoracic vertebra. Vibratory sensation was lost in the lower extremities and sense of position in the great toes. There was no dysmetria in the finger to nose test; no astereognosis and no adiadokokinesis. The biceps and triceps tendon reflexes were markedly exaggerated. Patellar reflexes were exaggerated but rather hard to obtain on account of the spasticity. Attempts to cause the Achilles reflex caused continuous ankle clonus. There was a positive Babinski sign on both sides.

Roentgen-ray examination of the thoracic spine was negative.

Spinal Fluid: Five cells; pressure, 8 mm. of mercury; the fluid was yellow tinged. The Wassermann test was negative; globulin test, positive; sugar was present. The blood Wassermann test was negative.

Operation and Course.—On April 12, 1921, a laminectomy was performed. The spinous processes and laminae of the fifth, sixth and seventh thoracic vertebrae were removed, and on opening the dura there appeared at the level of the spinous process of the seventh thoracic vertebra a tumor on the posterior aspect of the cord, more to the right than to the left. It was 3 cm. in length and had the naked eye appearance of an endothelioma (Fig. 18). It was removed intact. The surface of the cord in contact with the tumor was irregular and gave one the impression of rather pronounced degenerative changes. The wound was closed.

Pathologic Diagnosis: Endothelioma.

Postoperative Notes: The patient's recovery from the operation was uneventful, but a year after operation there had been no recovery of function.

Case 12.—*History.*—G. V., aged 50 years, referred to the neurosurgical service of the University Hospital, Sept. 6, 1921, by Dr. Alfred Stengel, one or two years before was told that she was walking as if very tired and not using the right foot quite so well as the left. She walked little and paid little attention to this condition. On Thanksgiving Day, 1920, while at work, she had pain in the lower right side of the back, which made walking difficult. She was treated for renal calculus. All this time she had a sensation as of a belt or pressure radiating from back around the region of the waist, not crossing the midline. Three weeks later she was taken to the stomach hospital where a diagnosis of neuritis, rheumatism and deep seated lumbago was made. She had pain through the entire lower right part of the abdomen and back. She remained in the hospital three weeks. About this time she began to have increasing pain before bowel movements. The pain started in a spot in the lower right side of the back, radiated around to the front at the level of the umbilicus, then spread up under the right ribs, giving the sensation of a tight jacket and spreading over the entire right side of the back. There was more pain at night; every two hours she was awakened by it. She was relieved by a hot water bag. The pain was less frequent during the day (Fig. 19).

In September, 1921, the patient was readmitted. There had been no change in her condition except that she had more difficulty in walking.

Examination.—It was impossible to obtain an accurate record of the sensory disturbances since the patient's mental condition was such that her answers were frequently contradictory. However, there were times when the sensory findings suggested a Brown-Séquard syndrome and a tumor at the level of the ninth thoracic segment. Patellar and Achilles reflexes were increased on both sides. The Babinski sign was present on both sides. At times there was a nonpersistent ankle clonus.

Spinal Fluid: Pressure, 6 mm. of mercury; no xanthochromia. Five cells per cubic millimeter. The Wassermann and colloidal gold tests were negative.

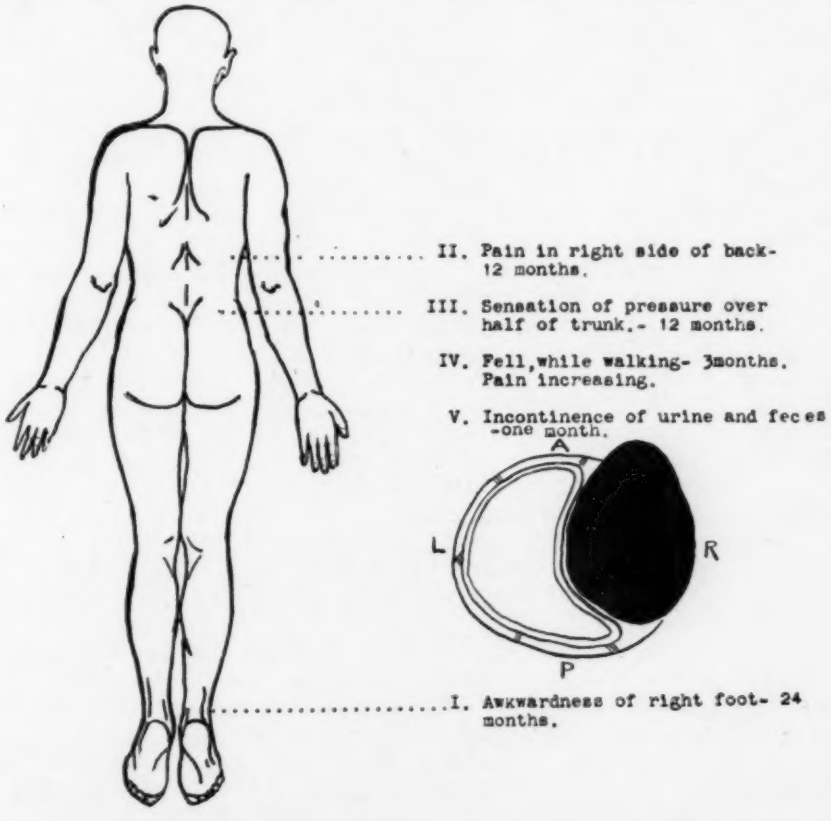
II. Pain in right side of back- 12 months.
III. Sensation of pressure over half of trunk.- 12 months.
IV. Fell, while walking- 3months. Pain increasing.
V. Incontinence of urine and feces -one month.
A
L
R
P
I. Awkwardness of right foot- 24 months.
Tumor involved segment T 12.

Fig. 19.—Chronologic sequence of symptoms and diagram showing relation of tumor to cord.

Roentgen-ray examination of thoracic spine suggested rarefaction of the fourth thoracic vertebra. It was observed that the slightest motion of the patient caused exquisite pain, as did jarring of the bed.

Operation and Course.—On Nov. 22, 1921, a laminectomy was performed. Spinous processes and laminae of the fifth, sixth, seventh and eighth thoracic vertebrae were removed. At this level, on opening the dura there was no evidence of tumor. On removal of the spinous processes and laminae of the ninth thoracic vertebra an extradural growth was discovered, chiefly on the

right side, having the appearance of a sarcoma involving the laminae of the eighth and ninth thoracic vertebrae. The tumor had compressed the cord on the right side and encroached on more than half of the spinal canal. As much of the tumor as was accessible was removed in order to give immediate relief of pressure. The tumor unquestionably took its origin from the vertebral column, and before closing the wound 50 mg. of radium, in a metal container within a rubber tube, long enough to reach to the surface, was applied about 1 inch above the level of the cord; the tube of radium remained in this position for twenty-four hours.

Report from a frozen section was returned, "sarcoma."

Postoperative Notes: Because of persistence of pain following the operation, it was decided to attempt relief by section of the anterolateral columns of the cord. In December, 1921, laminectomy was performed at the level of the fifth thoracic segment, and the anterolateral columns on both sides were sectioned by our prescribed technic. This operation gave the patient substantial relief. From the time of its performance until her discharge from the hospital, she was comparatively comfortable.

Case 13.—*History.*—A. J. H., aged 37 years, admitted to the neurosurgical service at the University Hospital, Dec. 4, 1920, was well until the summer of 1917, when she noticed that the right great toe was stiff when she attempted to rise on the toes in playing tennis or golf. No pain was associated with the stiffness, which disappeared after a short time. In December, 1917, she noticed that in skating she could not balance properly. During the early months of 1918 there was the same difficulty in skiing. There was no difficulty in walking. In the fall of 1919 there appeared stiffness in the thighs anteriorly. In dancing she could not move with her usual spring. About this time there were occasional cramplike pains in the feet during exertion, relieved by taking off the shoes. She could walk without difficulty on level ground, but going up inclines and stairs was difficult. There was no pain in the legs. Since August, 1919, she has used a cane. In the spring of 1920 there was no voluntary movement of the toes and ankles, knees or hips. There has been no loss of power in the hands, arms or trunk, though movements of the lower spine are sometimes clumsy.

There has been some tingling in both legs. During the early part of the trouble there was hypersensitiveness in the soles. She has no difficulty in appreciating temperature. When the legs are down there is redness, even cyanosis, with cold skin, though they feel warm subjectively; vice versa, occasionally the parts seem cold, but the skin is warm.

Occasionally there have been kicking, jerking movements at the knee. There are no symptoms referable to other organs.

Lumbar Puncture: Pressure, 6 mm. of mercury; clear, colorless fluid; cells, 8 per cubic centimeter. There was a trace of globulin, the Wassermann and colloidal gold tests were negative.

Roentgen-Ray Report: Dorsolumbar spine negative.

Notes by Dr. Spiller: There was considerable spasticity of the lower limbs, more of the right. There was slight voluntary movement of the toes, of both ankles and of the knees and hips. The patellar reflexes were distinctly and equally exaggerated; patellar clonus was persistent on the right and indicated on the left. Ankle clonus and the Babinski sign were present on either side.

Heat and cold sensations were greatly diminished on both sides, almost to Poupart's ligament; they were normal on the abdomen. Pin prick sensation was nearly normal in the lower extremities. Tactile sensation was the same

as that for heat and cold. Sense of position was lost in each big toe. There was perfect control over the bladder and bowels. In the peri-anal region of each side there was slight impairment of touch, apparently none of pain. There was considerable impairment in the peri-anal region to heat and cold. There were no deformity of the vertebral column and no tenderness over the spine.

The symptoms were those of an incomplete lesion of the spinal cord about the first lumbar or twelfth thoracic segment. Control of bowels and bladder indicated incompleteness of the lesion. There had been burning pain in the feet in the early stage of development, during exertion and when in bed. If the symptoms resulted from pressure on the cord, one would expect greater spasticity. The indications were rather that there was an intramedullary lesion, a partial transverse myelitis. A tumor was possible but seemed doubtful. Voluntary movement in the lower limbs had been increasing.

Operation and Course.—On Dec. 14, 1920, a laminectomy was performed. A left, extradural tumor was exposed and removed. Assuming the tumor to be at the level of the first lumbar segment, it was planned to remove the spinous processes and laminae of the eighth, ninth and tenth thoracic vertebrae. This was done, beginning above and going down, and when the tenth lamina was removed there appeared projecting from below a bluish tumor which seemed to occupy approximately three fourths of the spinal canal, the cord being compressed well over to the right side. The tumor began at the lower margin of the laminae of the tenth thoracic and extended down for a distance of 6 cm., necessitating removal of the laminae and spinous process of the eleventh thoracic. The shape of the tumor was rather peculiar in that there projected to the left and forward a tonguelike process like the stalk of a mushroom. So far as could be seen, it was entirely encapsulated, and the tumor was removed intact. Two bleeding points were controlled with muscle grafts. The wound was closed with five layers of interrupted silk sutures. Tubular drainage was employed.

Postoperative Notes: There was an extraordinarily rapid recovery of function. Three weeks after the operation the patient could walk, and sensation was entirely normal with the exception of an area of hyperesthesia over the left ankle and foot.

Case 14.—*History.*—J. G. R., aged 49 years, admitted to the neurosurgical service of the University Hospital, May 18, 1921, was in good health until 1918, when he noticed a sharp pain in his thigh and groin, radiating to the crest of the ilium on the right. This was worse when he stooped, worse one day than another and worse at night. He preferred to sleep sitting. At times it would subside almost entirely, and he continued at work. This condition continued about six months. He then grew a little better. In the winter of 1918-1919 the pain grew a little worse, and his right leg would often tremble when he preached. This pain would be relieved by aspirin. In the spring of 1919 the pain and trembling grew better, and during the whole summer of 1919 the symptoms were mild. In the fall of 1919 the pain grew so severe that he could not lie down. In January, 1920, he was cystoscoped, with negative findings. He also suffered with retention of urine. He had a little pain in his legs at that time. The retention passed off in a month or so, and he was able to return to work in March.

In October, 1920, the trouble returned, and he worked with difficulty until January, 1921, when he stopped work for two months. He then worked throughout April. On May 8 the pain came on again rather suddenly and increased rapidly. On May 12 his feet began to itch and sting. On the

thirteenth he noticed that they were growing weak, and on the fifteenth they became paralyzed. When admitted he had pain in both legs and lower part of his back and a band sensation about his waist. He had lost from 3 to 5 pounds (1360.7 to 2267.9 gm.) since the beginning of his illness.

Examination.—This revealed a man of small stature, in not very robust health and suffering much pain. His mind was clear. There was complete flaccid paralysis of both legs. His head, cranial nerves and chest were normal. There was a mass in the upper left part of the abdomen extending to midline and below the umbilicus. It had a rounded edge but no definite notch.

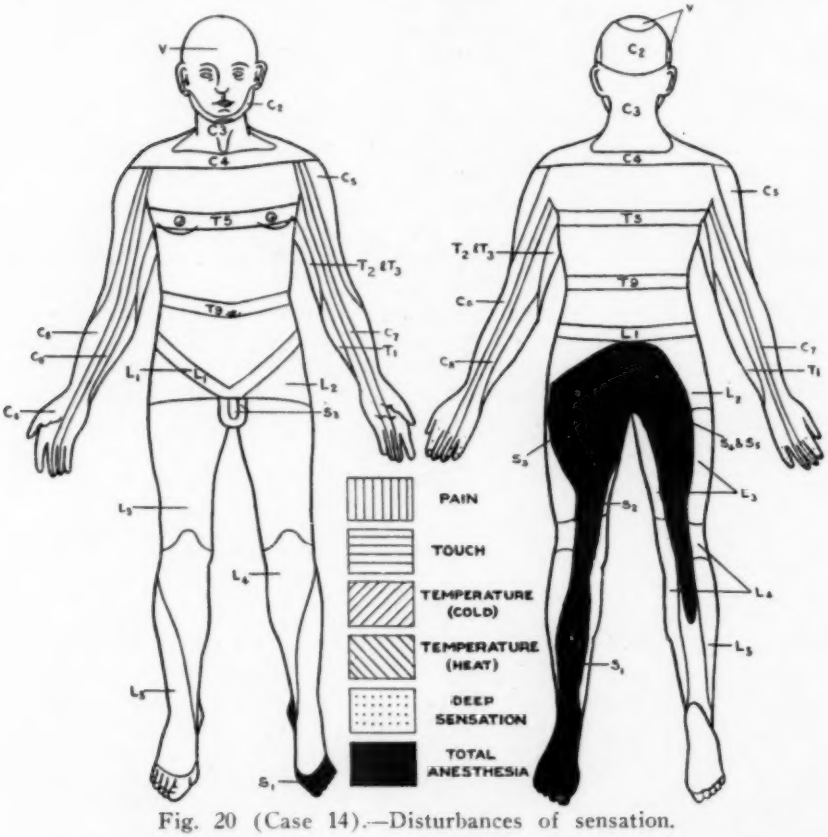

Fig. 20 (Case 14).—Disturbances of sensation.

It moved slightly with respiration. There were no nodules or irregularities. Abdominal reflexes were absent. The genitalia were normal. No cremasteric reflexes were present.

Power was good in both hands. There was no wasting or atrophy. The reflexes were prompt and equal, right and left (biceps and triceps). There was a slight intention tremor in both hands. No adiadokokinesis or dysmetria was present.

There were flaccid paralysis (complete) and some wasting of both legs. There were fibrillary tremors in the calves. No Achilles reflexes or Babinski sign were present. Sense of position in the toes was gone (Fig. 20). Total anesthesia was found in the area shown in the chart. Sensation over the rest of the body was normal. Patellar reflexes were subnormal and equal.

Fig. 21.—Photograph of cord.

The patient said that sexual intercourse was possible until two months before or less, but caused much pain afterward. Erection and ejaculation both occurred.

The spine of the second lumbar vertebra seemed slightly more prominent than its neighbors, but no actual kyphosis was present.

Dr. Pepper: Review of the history elicited the statement that the paralysis came on quite abruptly (six hours) after osteopathic manipulation of the spine.

Examination.—Results of examination agreed with the foregoing except that the cremasteric reflexes were present, and the patellar reflexes were obtained with great difficulty. The mass could be certainly diagnosed as kidney or spleen. The patient was more anemic than the first blood count suggested and the urine contained large amounts of blood. Apparently the pain could be due to the same lesion that had produced the paralysis.

The spinal fluid was bile colored. There were four cells per cubic millimeter; globulin was present; pressure, 4 mm. of mercury. There were 4,720,000 red blood cells, 14,600 white blood cells and 96 per cent. of mercury.

The patient had to be catheterized. The urine was cloudy. Four days later the bladder contained much blood and clots. This continued until May 25, 1921, when the bleeding stopped, and the urine became clear. Urine: Appearance, cloudy red; sediment, granular; specific gravity, 1.021; reaction, acid; albumin, cloudy; sugar, negative; red blood cells, from 30 to 40; white blood cells, loaded; epithelium, occasional; no acid-fast organisms in twenty-four hour specimen.

May 29, 1921: Bleeding commenced again, but ceased June 1, 1921. Hypodermic injections caused a rather large hematoma under the skin. Therefore the large amounts of morphin which were necessary to relieve the patient's pain were given by mouth.

He complained of unbearable pain when he lay down, but if he lay down with his head raised on a pillow and his thighs flexed, he was not quite so uncomfortable. He found it necessary to sleep propped up in bed to almost an erect position. Catheterization twice and sometimes three times a day was necessary.

Operation and Course.—Because of the hematuria and the mass in the left upper abdomen, a provisional diagnosis of a hypernephroma with cord metastasis was made. An exploratory operation was performed by a member of the surgical staff, and the enlarged organ was found to be the spleen. Following its removal the patient died, and at necropsy a tumor of the lower segments of the cord and cauda equina was found. The tumor measured 6 cm. in length and proved to be a sarcoma (Fig. 21).

DISCUSSION

Dr. M. A. Bliss, St. Louis: Did Dr. Frazier fail to find a tumor in cases which presented a typical Brown-Séquard syndrome? I have seen such cases, but the symptom level rose higher in the cord after operation. Did a cyst of the cord appear in any of his cases? In one such case we had brilliant results, with return of sensory function in a few days and return of motor function within a month, and with restoration from a totally paralyzed state, to walking. A year later, recurrence showed epithelioma.

Dr. Julius Grinker, Chicago: I had an experience with a case of spinal cord tumor which leads me to believe that Dr. Frazier need not despair of recovery in some of his operative cases. In that case an operation was done, and for fully a year and a half there was not a sign of improvement, the

patient being completely paraplegic. Then, to our surprise, the nurse noticed that one great toe began to move, and from that time on there was gradual improvement, and within another year and a half the patient had recovered sufficiently to walk with assistance. I have no doubt that there are cases in which recovery does not occur, but we should never despair, for that recovery may eventually take place. I cannot explain why in some cases improvement should be so long delayed.

Dr. F. E. Coulter, Omaha: What has Dr. Frazier's experience been relative to trauma acting as an etiologic factor?

Dr. Leo M. Crafts, Minneapolis: I recall the case of a farmer who, while a group of men were lifting a section of barn floor, reached under it; the workmen accidentally let the section down on him, doubling him over very sharply. When released, he had a sense of discomfort and pain all about the midbody. This feeling continued. A few months later he had developed a typical picture of cord tumor. A laminectomy was done in the middorsal region, and a hypernephroma was found extradurally, postlateral, toward the right. He had a complete paraplegia which showed no improvement for six months or more; then he began to improve, and continued to gain until he had fairly good use of the legs. Some months later the picture recurred and progressed. It would seem that unquestionably trauma was the etiologic factor.

Dr. A. W. Adson, Rochester, Minn.: Dr. Frazier emphasized an important point in stating that pain is a very valuable sign. The tendency has been to wait until the patient developed a level sign in addition to pain, that is, loss of pain, tactile and temperature sensibilities, before we felt free to make a diagnosis of cord tumor. In reviewing 112 laminectomies which were performed at the Mayo Clinic for cord tumor, I find that fourteen were situated extradurally, thirty intradurally but extramedullary, and thirty-one intramedullary; in twenty-seven instances a tumor was not found, the condition being chronic meningomyelitis. In four of this group, tumors were found later—three cases of varicose veins of the cord, two tuberculomas, two gummas, one echinococcus cyst and two cerebellospinal tumors. Root pain was present as a symptom in eight of the extradural group, in twenty of the intradural group, and in twenty-two of the intramedullary group. Of the group in which no tumor was found, pain was present in thirteen patients. This is evidence that pain is a very valuable symptom. During the past year we have explored and removed four tumors from patients who had no sensory loss and who presented a history of pain without any other symptoms, which is significant of pain being an important and valuable sign. When a patient complains of pain, which is aggravated by stooping, coughing, sneezing and when lying down, which is relieved by getting up and walking about, and not by usual remedies, when the pain is in the sciatic nerve, the possibility of cord tumor must be borne in mind.

Dr. Hugh T. Patrick, Chicago: Was any motor loss manifested in those cases in which there was no sensory loss?

Dr. Adson: No, there was no motor loss. One patient stated that for two months he did develop a little patch of anesthesia over the lumbar nerve, but he came primarily for pain and was at first treated for sciatica.

Dr. Patrick: I was surprised that Dr. Frazier's table showed only one case in which pain did not antedate motor loss. I have no statistics to present, but I feel quite sure that my cases show a fair proportion in which motor impairment came before pain. Possibly in interpreting just what pain

is, Dr. Frazier and I may have a little different attitude. Any patient who is spastic (and there are many patients with motor impairment who are spastic) will spontaneously make the statement that he has a pain in the back or between the shoulders or below the small of the back, which, like many other statements of patients with reference to pain, may be shown to be not pain at all in the proper sense; that is, these patients have a distressing sensation, and in their vocabulary a disagreeable or uncomfortable feeling is called pain. This sensation in spastic patients is frequently due to the spasticity—the muscular tension in the muscles of the back. In my opinion that is to be distinctly distinguished from anything like a root pain or pain due to any sort of nerve encroachment. Relative to multiple tumors of the spinal cord, which condition has been one of the disappointing and perplexing features of two of my cases, I should like to ask Dr. Frazier whether he has had tumors which were at first, microscopically and macroscopically, supposed to be the ordinary endothelioma, and later proved to be gliomatous. One patient was operated on with success. There was a recurrence, and we operated the second time with almost as brilliant a result. A third operation was done after recurrence of symptoms, but the surgeon reported that the cord had become infiltrated with a growth and no operation was possible. However, for a long time afterward the patient did very well under roentgen-ray therapy. Dr. Frazier informed me that his one patient who showed no pain at any time was another case in which I failed to make the diagnosis. Fortunately, however, she eventually consulted Dr. Frazier and Dr. Spiller, who did make a diagnosis. When I examined her she had absolutely no pain, as she informed me she had not subsequently. She had no sensory loss of any sort. She had a spastic paraplegia of moderate degree, was serologically negative, and the spinal fluid showed no indications of tumor. As most such cases in young persons (this was a relatively young woman) eventually turn out to be multiple sclerosis, I supposed she had that disease. I did not have the opportunity of following the case, and consequently had the discomfort of knowing that I had not diagnosed it properly. But I had the comfort of knowing that after operation she made a brilliant recovery.

Dr. Charles H. Frazier, Philadelphia: What Dr. Patrick said in regard to the possibilities of misinterpretation of the symptom of pain is very significant. No doubt there may have been cases in my series in which what we termed pain or what the patient thought was pain was not the pain of a root phenomenon. Yet, it is rather significant that the location of pain was found to be constant throughout the history of the case, and was always helpful in diagnosis. I do not think that Dr. Patrick ought to take himself to task for not having made an accurate diagnosis in the case to which he referred, and in which I subsequently operated. He saw the patient at a very early stage of the disease, while I saw her at a late stage, when there was an indefinite level of impairment. And I think it is only fair to Dr. Patrick to make this acknowledgment, that in this case I was unwilling to commit myself, and told the family of the patient the lesion might be of three possibilities: an intramedullary tumor, an extramedullary tumor or a myelitis. I was quite sure of the level of the lesion, but not of its nature. But since the symptoms were progressive and the patient totally disabled, we felt that an exploratory operation was justified. We found an extradural tumor, which was readily removed. Dr. Bliss has asked a pertinent question: Whether or not we have failed to find tumor in cases which presented a typical Brown-Séquard syndrome. I cannot answer this question as accurately

as I would like to do because I have not the details of all the cases in mind. However, I recall one case in which the symptoms of cord tumor, including the Brown-Séquard syndrome, were very definite, when we failed to find any evidence of tumor at the exploratory operation. The patient died about a year later, but unfortunately we were unable to secure a necropsy in that case. Most of the cases in which we failed to find a tumor, at the exploratory operation, are those in which there was not a definite level of sensory loss. Referring to the case cited by Dr. Grinker, I was surprised to hear that recovery of function had been deferred a year and a half after operation. When symptoms are due to pressure alone one would expect recovery of function to be rather prompt and rapid. When symptoms are due to degenerative changes, we would not anticipate recovery of function at any time. As to the relation of trauma to cord tumor, I have no knowledge. In one of the cases of this series there was a very definite history of trauma. However, no particular significance was attached to it. I think it is interesting to note that sometimes those who practice manipulative therapy help to make the diagnosis. There were two cases in our series in which great aggravation of symptoms followed immediately on the institution of such treatment.

THE MECHANICAL EFFECTS OF TUMORS OF THE SPINAL CORD

THEIR INFLUENCE ON SYMPTOMATOLOGY AND DIAGNOSIS*

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NEW YORK

In order to localize accurately a spinal cord tumor—and by "localization" we mean not only the diagnosis of the level of the new growth but also the exact relations of the growth to the cord—a definite classification of the position of such growths with reference to the surfaces of the spinal cord is necessary. We have, for many years, grouped our tumor cases in the following manner (Fig. 1, *A* and *B*).

All growths on the posterior aspect of the cord, whether in the median line or laterally, behind the posterior nerve roots, are classified as posterior growths; those that lie on the lateral aspect of the cord, in front of the posterior roots but behind the dentate ligament, we call

TABLE 1.—RELATION OF TUMORS TO THE SURFACES OF THE CORD (NOT INCLUDING THOSE BETWEEN THE ROOTS OF THE CAUDA EQUINA)

Location	Extramedullary	Extradural
Anterior and median	1	1
Anterior and lateral	5	4
Anterolateral	6	2
Posterior and median	1	0
Posterior and lateral	18	3
Posterolateral	8	3
Lateral and posterior	1	0
Lateral or around the cord	1	1
Totals	41	14

dorsolateral growths; those that lie laterally, in front of the dentate ligament but behind the anterior roots, we call ventrolateral growths; finally, those that lie on the anterior aspect of the cord, in the median line or more laterally but *in front* of the anterior roots, we call anterior or ventral growths. While tumors may occupy more than one of these locations, it is usually possible—excepting in tumors between the roots of the cauda equina—to place them in one of these categories. In our series of spinal cord tumors, 64 per cent. of the growths lay dorsally or dorsolaterally, and 36 per cent. were ventral or ventrolateral (Table 1 and Figure 2, *A* and *B*).

There are, therefore, a considerable number of patients with spinal cord tumors in whom the growth develops in a location away from the posterior spinal roots, and hence a comparatively large group of cases in which early posterior root irritation will not occur.

* Read at the Forty-Eighth Annual Meeting of the American Neurological Association, Washington, D. C., May, 1922.

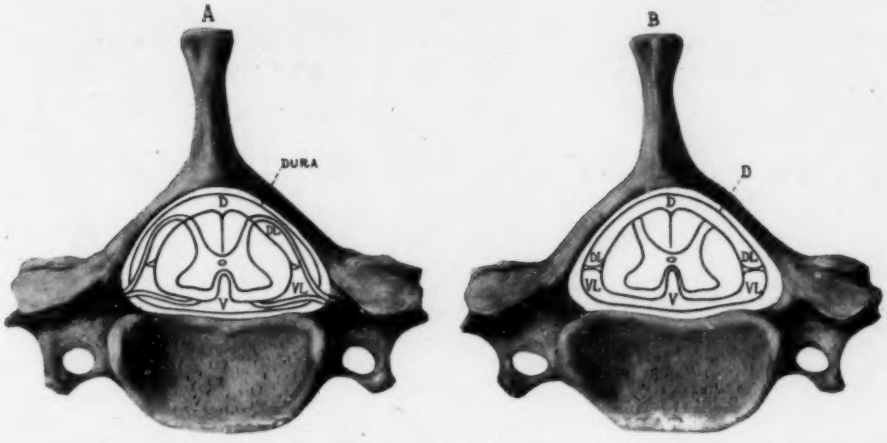

Fig. 1.—Diagrammatic classification of tumors in relation to the cord: *A*, at the level of a nerve root; *B*, at the level of a slip of the dentate ligament; *V*, ventral or anterior; *D*, dorsal or posterior; *VL*, ventrolateral or anterolateral; *DL*, dorsolateral or posterolateral.

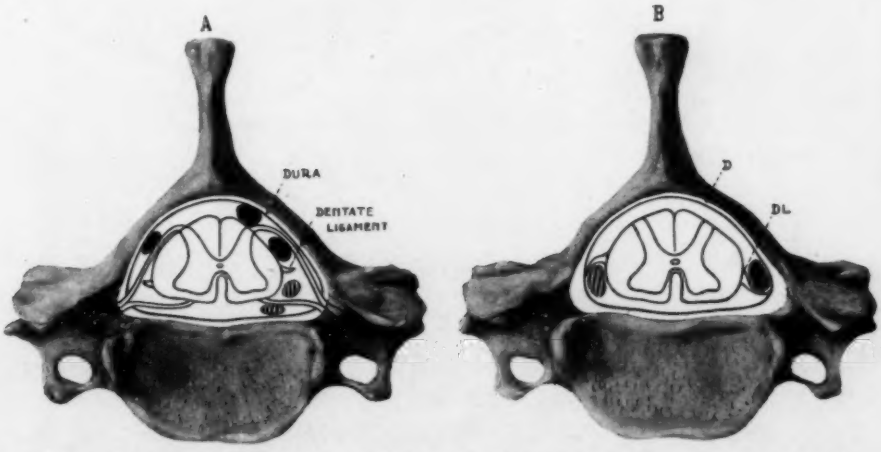

Fig. 2.—Diagrammatic representation of the frequency of tumors in the different locations. The dorsal and dorsolateral growths (in black) form 64 per cent. and the ventral and ventrolateral growths (in black and white) form 36 per cent of the tumors.

THE FREQUENCY OF SUBJECTIVE SENSORY DISTURBANCES

Many years ago, Pearce Bailey and others called attention to the fact that cases of spinal tumors may have a painless onset, and cases of this kind are not rare. A study of our series, however, showed that while pain is often absent there are very few patients who do not have some kind of sensory disturbance as an early symptom of the disease (Table 2).

Table 2 shows that paresthesias of one kind or another were very frequent in the extramedullary tumors in our series. Such paresthesias, especially if they occurred without pain, were formerly supposed to indicate disease within the substance of the spinal cord. The study of our cases, however, has led us to modify considerably our views on this subject. We have learned that in ventral and ventrolateral growths, subjective paresthesias are very frequent.

TABLE 2.—SENSORY SYMPTOMS AT ONSET

	Extra-medullary	Extra-dural	Conus and Cauda	Intra-medullary
Root pains	19	3	0	2
Pain in back or in neck	6	4	1	4
Pain in back, extending down limbs	1	2	7	0
Pain in homolateral limb below level	1	1	0	0
Pain in contralateral limb below level	2	1	0	0
Pain in both legs below level	2	0	2	0
Pain in rectum	1	0	1	0
Pain in chest or abdomen	2	2	0	1
Tingling, burning, heaviness, pin and needle sensation or numbness, homolateral limb below level	1	0	0	4
Tingling, burning, heaviness, pin and needle sensation or numbness, contralateral limb below level	5	0	0	0
Tingling or numbness, both lower limbs	3	0	0	2
Tingling without pain on same side	1	0	0	0
Tingling without pain on opposite side	2	0	0	0
Numbness or heaviness, no pain	1	1	0	0
Feeling of stiffness, no pain	1	0	0	0
No sensory symptoms	1	0	2	2

Table 2 shows that in a number of patients the first subjective sensory complaint was a tingling or burning in the lower limb of the opposite side. We were at first at some loss to explain this contralateral symptom. Five of six patients with ventrolateral growths had this contralateral tingling, and in several recent patients we have been able to localize correctly the tumor from this symptom.

Tumors that lie on the ventrolateral or the dorsolateral aspect of the cord are much more apt to give an early Brown-Séquard type of motor and sensory disturbance than tumors in other locations. If the disease began with root pains, the tumor usually lay dorsolaterally; if, on the other hand, early root pains did not occur, but there were early contralateral paresthesias, the growth usually lay on the ventrolateral aspect of the cord (Figs. 3, *A* and *B*).

Rarely, an extramedullary tumor may develop without causing any pain or any subjective or objective sensory disturbance for a long period.

These patients have, for many months and sometimes for years, a slowly progressing spastic paraplegia without any disturbance of cutaneous or deep sensation. We have seen two patients of this type, and in both of them the diagnosis of spinal compression was made only after a prolonged period of observation. In one of the patients, objective sensory disturbances appeared only after a lumbar puncture had been performed. In the second patient, no sensory disturbance could be detected for several years, although it was repeatedly looked for.

THE MOBILITY OF THE SPINAL CORD AND THE MECHANICAL EFFECTS OF CORD TUMORS

The mobility of the cord, at various levels, has a great influence on the symptoms and signs of an expanding lesion within the spinal canal.

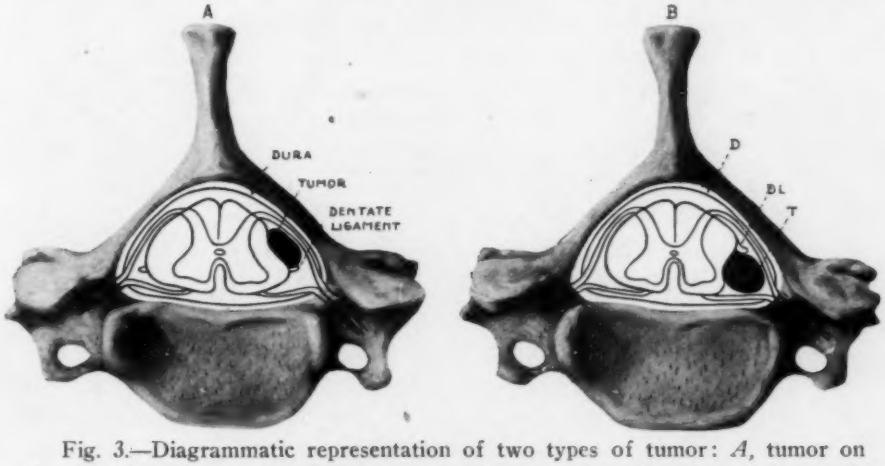

Fig. 3.—Diagrammatic representation of two types of tumor: *A*, tumor on the dorsolateral aspect, and *B*, tumor on the ventrolateral aspect of the cord, that are likely to give an early Brown-Séquard picture. Type *A* usually begins with root pains, Type *B*, often with contralateral parenthesias below the level.

Both from our anatomic investigations and from our observations on the operating table, it may be said that a cord segment is most movable in anteroposterior and lateral directions, at the level of each pair of spinal roots. Our attention was first called to this fact in a patient in whom we wrongly localized a growth on the posterior aspect of the cord on account of well marked posterior column disturbances. At the operation, the tumor was found and removed from the anterior surface of the cord. It had pushed the cord backward so that the posterior columns were pressed against the dura and posterior bony wall of the vertebral canal. There was, in this patient, a complete loss of vibratory and articular sensibility due to this compression of the posterior columns of the cord at the affected level against the bony wall of the spinal canal.

On account of the mobility of the cord, the dislocation of segments of the cord by the direct pressure of a soft tumor may, as in the instance we have cited, cause confusing sensory disturbances.

There is another type of cord dislocation, however, which is not due to direct tumor pressure and the physics of which is not at all clear to us. We first began to investigate this subject some years ago when one of us operated on a patient with an extradural tumor on the lateral aspect of the cord, in whom motor disturbances first occurred on the contralateral side of the body, and in whom, at the time of our first and of succeeding examinations, the most advanced motor disturbances were on the opposite side of the body and the most marked sensory loss on the same side as the tumor. This "reversed Brown-Séquard" syndrome could only be explained on the basis of a greater involvement of the lateral columns of the cord on the side opposite that on which the tumor lay, and an explanation for this condition had to be sought for in the mechanical changes that might be produced by a growing spinal cord tumor. In all, we have observed and operated on six patients with this "reversed" Brown-Séquard picture. Two of the patients had extradural growths, and in four the tumor was intradural but firmly adherent to the inner surface of the dura.

Although we are fully cognizant of the law of physics that in a fluid medium pressure is transmitted equally in all directions, we do not believe that this law can be made to apply fully to the conditions which exist within the spinal canal where there is a fluid medium—the cerebrospinal fluid—and a more solid structure—the spinal cord—which is partly held in place by nerve roots and by the dentate ligament. In addition, it is important to remember that the fluid medium which surrounds the cord is more or less in motion, and that, in general, there is a constant movement of fluid in a downward direction (caudad) on the posterior aspect, and upward (cephalad) on the anterior surface of the spinal cord.

Without attempting to solve the physics of the process, we believe that the following is the only possible explanation for the symptomatology in the six patients above referred to.

In Figure 4, *A* represents an extradural tumor on the left side of the dural sac in the earliest stages of its growth. When the growth has reached a certain size and before actual pressure on the cord by the tumor has occurred, the cord has changed its position and lies against the dura and the bony wall of the canal on the side opposite that of the tumor (Figure 4 *B*). The actual physical condition that now exists is this: The right side of the cord is in contact with a firm bony resistance, while the left side is more or less protected by a fluid water pad, which distributes the pressure over that side of the cord. At this stage,

and as a natural result, the right side of the cord is more involved, and symptoms referable to that side of the cord are more prominent.

A similar condition may obtain in the case of a growth which is firmly adherent to the inner surface of the dural sac and is not yet of large size (Fig. 5, *A* and *B*). If, on the other hand, the growth begins from the pia, or from the arachnoid which is bound to the pia by numerous fine trabeculae, the cord is pushed to the side opposite that of the tumor only by the tumor itself when it (the tumor) has reached a certain size (Fig. 6, *A*, *B* and *C*).

The conditions illustrated by Figures 4 and 5 will explain the contralateral symptoms that we have observed in six of our patients. We have, as a result, arrived at the conclusion that a spinal cord tumor

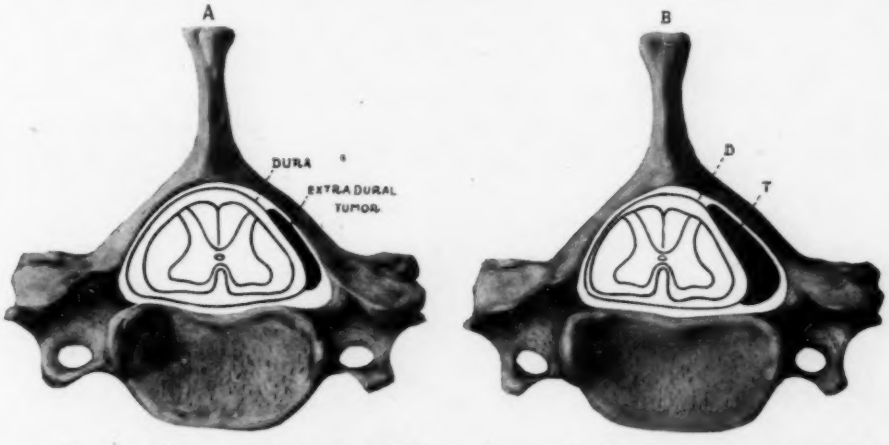

Fig. 4.—Diagrammatic representation of an extradural tumor on the left side of the cord: *A*, an early stage of its growth (to the right in the diagram); *B*, a later stage, when the cord has changed its position so that the right side is in contact with the dura and the bony resistance, while the left side is more or less protected by a water pad of fluid.

which begins with root pains on one side and motor disturbances on the opposite side of the body is probably an extradural or a dural growth.

THE INFLUENCE OF LUMBAR PUNCTURE ON THE SYMPTOMS AND SIGNS OF LOCAL SPINAL COMPRESSION

If the statements regarding the mechanical effects of extradural and of intradural tumors adherent to the dura are correct, then one should expect in these growths a marked influence on spinal cord symptoms after lumbar puncture and removal of the spinal fluid. This is actually the case. In ten of the patients of our series, the symptoms and signs of the spinal compression were aggravated after fluid had been withdrawn by lumbar puncture. Three of the patients had extradural

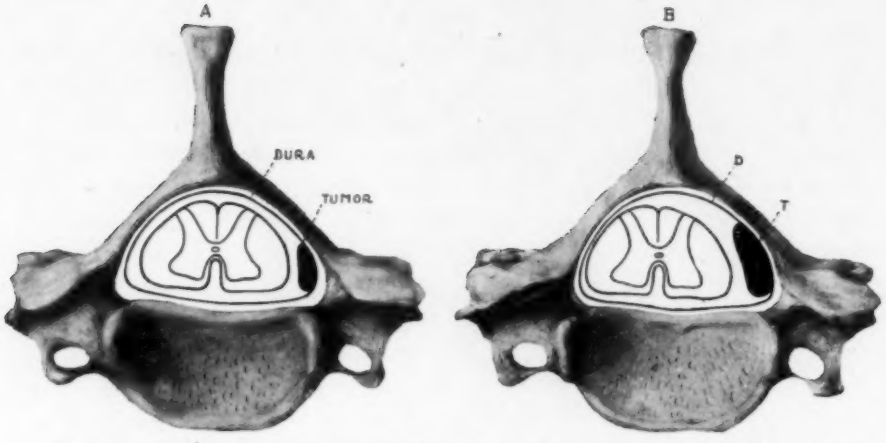

Fig. 5.—Diagrammatic representation of an intradural growth adherent to the dura. The movement of the cord to the right side of the canal (the left side on the diagram) is similar to that which occurs in extradural tumors. Compare with Figure 4.

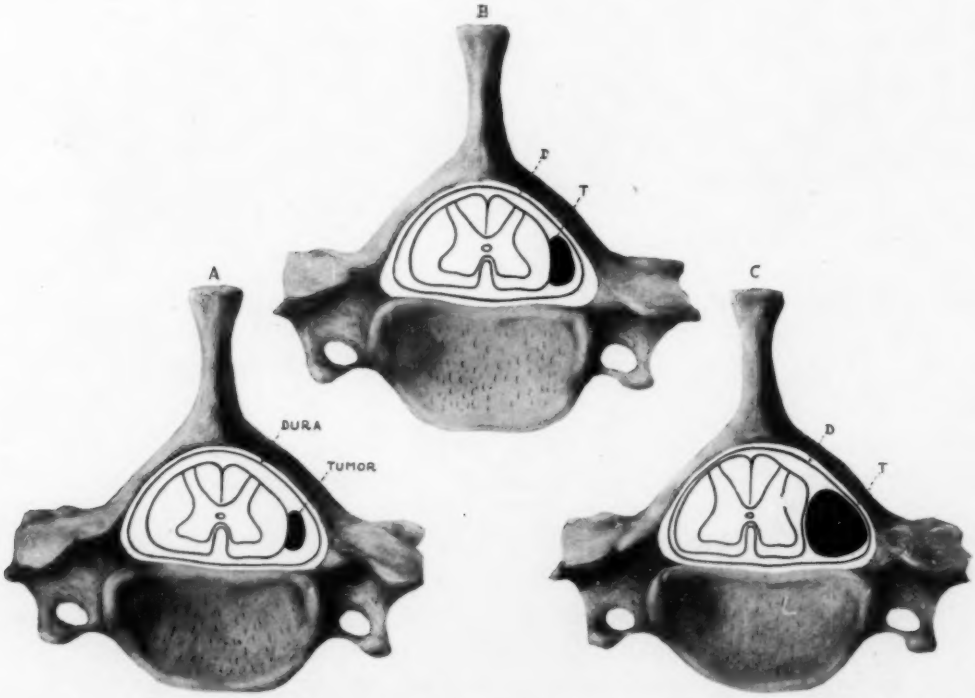

Fig. 6.—Diagrammatic representation of a tumor originating from the pia or arachnoid and adherent to the cord: *A*, *B* and *C*, different stages of growth, showing that the cord is pushed to the opposite side of the spinal canal only by the size of the growth; a different mechanism from that illustrated by Figures 4 and 5.

growths; in six, the growth was intradural but firmly adherent to the dura; in one patient, the record was incomplete. In some of the patients, the root pains became more severe after the lumbar puncture; in most of them, the neurologic signs became aggravated. Several patients who had had only moderately marked motor and sensory disturbances before the lumbar puncture became completely paralyzed soon after the withdrawal of fluid; and in one patient, already referred to, a loss of all sensation below the affected cord level developed within forty-eight hours of the puncture.

It is obvious that a growth adherent to the dura—either on its outer or its inner surface—which had not yet made much, if any, pressure on the cord itself, would exert a greater amount of pressure as soon as a certain amount of cerebrospinal fluid had been removed (Fig. 7). The

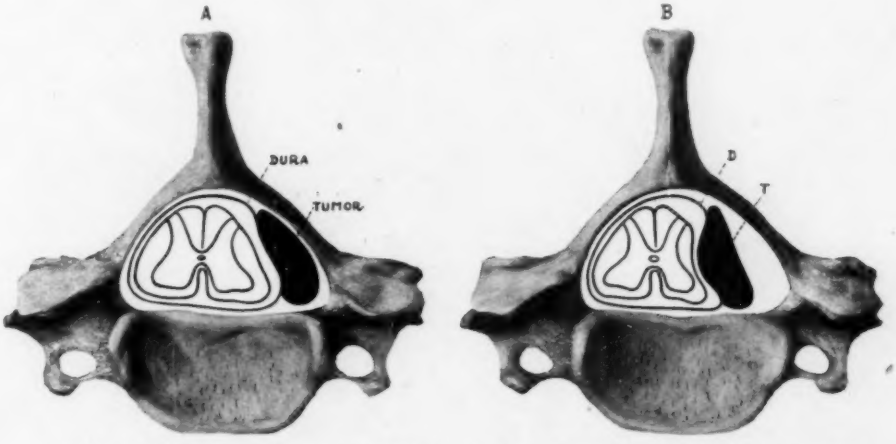

Fig. 7.—Diagrammatic representation of the change in position of an extradural tumor that may occur after lumbar puncture and withdrawal of fluid: *A*, before lumbar puncture, and *B*, after lumbar puncture.

condition would be entirely different in the case of most, or all, growths that were primarily attached to the pia or to the inner surface of the arachnoid, or were fixed against the cord by a slip of the dentate ligament or by a nerve root. In the latter instance, however, in spite of the trabeculae which unite the arachnoid to the pia, the withdrawal of spinal fluid by lumbar puncture might be followed, in the case of a small arachnoid growth, by an increase of preexisting symptoms and signs. In all our spinal tumor cases, we are now keeping careful records of any changes which may occur after lumbar puncture and we shall soon be in a position to state how frequently such changes occur and how often—if at all—they are observed in other than extradural or dural growths. From our experience thus far, however, we believe that if the symptoms and signs of motor and sensory disturbance become more

marked after a lumbar puncture with removal of fluid, the diagnosis that the growth is extradural or intradural, adherent to the inner surface of that membrane, is justified.

THE FREQUENCY OF TENDERNESS OF THE SPINES OF THE VERTEBRAE IN EXTRAMEDULLARY TUMORS AND THE LOCATION OF THE TENDER SPINOUS PROCESSES IN SPINAL TUMORS AND IN MALIGNANT DISEASE OF THE VERTEBRAE

As regards the presence or absence of tenderness of the spinous processes of the vertebrae in spinal tumors, our records are, unfortunately, not complete. In some of the patients, there was no record

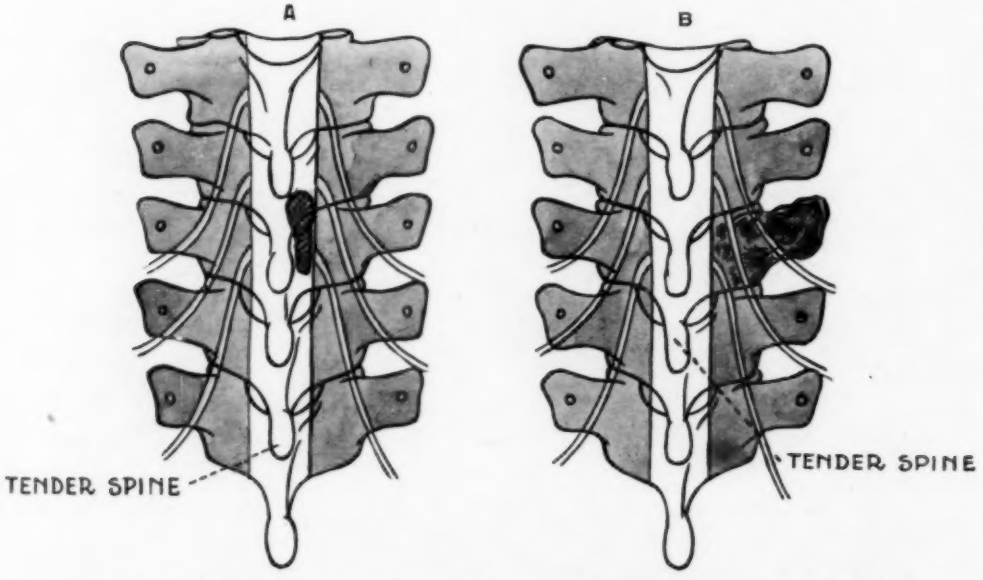

Fig. 8.—Diagrammatic representation of location of tender spine: *A*, the spinous process that is usually tender in an extramedullary tumor; *B*, the spinous process that is tender in malignant disease of the bone.

at all; in others, it was recorded that there was no tenderness. In twenty-four of fifty-two intradural extramedullary growths, one or more spinous processes were noted as tender. Of four patients with large tumors in the upper cervical cord, all of the cervical spines were tender in three; in one patient with a tumor at the second and third cervical segments, the second, third and fourth cervical spines were sensitive. In the large tumors which involve the conus and roots of the cauda equina and which usually filled up the lower end of the spinal canal, most, or all, of the lumbar and often the sacral spines were tender to pressure. In most of the patients with tumors of the thoracic or

lumbar cord, the spinous process that was tender actually corresponded to the segment affected, but not to the level of that segment. For example, with a tumor at the sixth thoracic segment, the sixth thoracic spine was tender, and with a growth at the twelfth thoracic segment it was the twelfth thoracic spinous process which was sensitive to pressure. In other words, in extramedullary intradural tumors, if any spinous process is tender, it is the one which receives its nerve supply from the posterior spinal root of the affected segment of the cord, and the tenderness is probably due to irritation of that sensory root by the manipulation of the spinous process. It is, of course, the posterior root which lies in proximity to, or is actually involved by, the tumor.

The location of the tender spines with reference to the level of the cord lesion is entirely different in malignant disease of the bony spine. In these patients, as we have often observed, the tenderness of the spine corresponds to the actual affected vertebra and is a real bone tenderness from the osseous lesion. This difference between the location of the tender spines in true spinal tumors, as compared with bone disease, is of considerable value for the differentiation between these two diseases. In spinal tumors, the sensitive spine is one, two or even three lower than the spine which is at the actual level of the affected cord segment; in bone disease, on the other hand, the sensitive spine is on the actual level with the affected cord segment (Fig. 8, *A* and *B*).

CONCLUSIONS

1. Tumors on the anterior and anterolateral aspects of the spinal cord are relatively frequent and form about one third of all cases.

2. Although many patients with spinal cord tumors have no pain at the onset, the large majority have some subjective sensory disturbance as an early symptom.

3. In some patients, objective sensory disturbances are absent for a long period and only appear after a lumbar puncture has been performed.

4. Tingling, coldness, burning and other paresthesias are not rare in extramedullary growths.

5. If the tingling occurs in the contralateral limb, below the level of the growth, there is considerable probability that the tumor lies on the ventrolateral aspect of the cord.

6. Intradural tumors adherent to the dura and extradural growths not infrequently press the cord to the opposite side of the spinal canal and cause early motor symptoms on the side of the body opposite that of the tumor.

7. If the signs of motor and sensory disturbances become aggravated after lumbar puncture and withdrawal of fluid, it is probable that the growth is either extradural or intradural, and adherent to the inner surface of the dural membrane.

8. Tenderness of a spinous process at the vertebral level of the lesion points to bone disease; tenderness of spines well below the vertebral level of the growth points to an intradural extramedullary tumor.

DISCUSSION

DR. HUGH T. PATRICK, Chicago: I should like to ask Dr. Elsberg about this tender area three spines below the level of the tumor; whether that applies to all levels, and how this tenderness has been elicited in his technic; whether by light percussion or by heavy percussion with the fist, or by pressure direct or lateral; whether, as his diagram indicated, this, occurring in the dorsal region where the spines descend a considerable distance below their bodies, the tender spine might really be from the vertebral body opposite the tumor.

DR. WILLIAM G. SPILLER, Philadelphia: The difficulty of diagnosis in some of these cases of tumor is extremely great. Where symptoms of root pain and loss of objective sensation in root or segment distribution are present, it may be only for temperature or pain bilaterally or unilaterally, with other symptoms, the diagnosis is comparatively easy.

I am quite in accord with Dr. Elsberg's view that in the absence of pain there is frequently paresthesia of limited or of root distribution, which may be of quite as much value clinically as the presence of severe pain in root distribution.

Dr. Elsberg did not explain the mechanism for his statement that a unilateral growth may produce paresthesia on the opposite side of the body. It is a question whether this is caused by the pressure on the cord by the tumor on the anterolateral column of the side where the tumor is, or is produced by the contralateral pressure on the posterior roots when the paresthesia is in root distribution. Where pain is bilateral from the beginning it seems to be indicative of a centrally situated tumor on the posterior part of the cord, irritating the posterior roots of both sides. Recently in a case in which I made the diagnosis of a central posterior tumor, at operation Dr. Frazier found the neoplasm located directly over the posterior part of the cord.

I have thought that extradural tumors may be less painful than intradural lesions. In two extradural growths that were removed recently by Dr. Frazier, there was a process which seemed to grow down into an intervertebral foramen. I am inclined to believe that these tumors originated probably from a spinal root and grew from and not into the intervertebral foramen, within the vertebral column where the resistance was less.

Pain and atrophy confined to a limb are extremely suggestive of tumor, and yet without other findings they may be most misleading and cause the greatest difficulty in localization. I recall a patient who developed severe pain and atrophy in the upper limb of one side, which I thought might have been caused by brachial neuritis or tumor. I could find no evidence of pressure on the cord and there was no involvement of the lower limb on the same or the opposite side and no sensory disturbances on the lower part of the body.

The patient recovered, the condition probably having been caused by neuritis of the brachial plexus. However, in two other cases in which a similar con-

dition existed, with one of which Dr. Strauss is familiar, it was a question whether the lesion was an extradural or an intradural tumor. In such cases the roentgen-ray examination should be of the greatest value, but the plates were not correctly interpreted at first and it was not until later that they showed the presence of an extradural tumor.

In cases of suspected tumor of the cord in which there are no valuable roentgenologic findings and no evidence of pressure on the cord, even though there may be some focal symptoms, as in the upper limb, it has seemed wiser to wait until we obtain evidence of pressure on the cord or roentgen-ray findings of diagnostic value. In such a case, while it is unfortunate to wait while the tumor may be growing, nevertheless it is also unfortunate to operate too soon.

Where there is complete paralysis or complete loss of sensation of several months' duration in the lower part of the body, we should not be pessimistic for I have seen such a condition disappear entirely after the removal of a tumor on the cord.

The most difficult diagnosis possibly is between tumor and focal myelitis or syringomyelia.

I should like to ask Dr. Elsberg whether the tenderness of the spine to which he referred might not have been caused by irritation of the roots at their exit from the vertebral column.

Dr. Morton Prince, Boston: According to Dr. Elsberg's diagram, his theory is that the extradural tumor presses on the fluid, and that the fluid transmitting the pressure to the cord shoves the latter across to the other side of the canal against the bony wall, with resulting contralateral pressure and contralateral symptoms. It seems to me, unless my knowledge of physics is incorrect, that such an action is an impossibility. As fluid transmits pressure equally in all directions, the pressure from the fluid should be equal all around the cord, from the opposite sides as well as from the side of the tumor. If this is true, the cord should remain suspended equally between the tumor and the opposite bony wall. If the cord were shoved across, it must have been by direct pressure of the tumor on it, and the symptoms should have corresponded.

Dr. Smith Ely Jelliffe, New York: Two series of observations concerning the possible aid that may be offered in the diagnosis of spinal cord tumors deal with alterations of the pilomotor reflexes and with the development of osteo-arthropathies about the joints and bony shafts. The studies, particularly of André Thomas[1] of the pilomotor, sudoral and local muscle reflexes throw much light on spinal cord localization problems, and the observations of Mme. Déjerine and Ceillier[2] on the osteo-arthropathies associated with spinal cord lesions are also of great interest. In two recently observed spinal cord tumors these newer findings were of value in accurate localization.

Dr. M. Allen Starr, New York: I should like to ask Dr. Elsberg whether in these diagrams the relation shown between the size of the cord and the size of the canal is anatomic or theoretical?

Dr. Elsberg, in closing: In the lantern slides that I have shown, the relation between the size of the canal and the size of the cord is neither anatomically nor theoretically correct. It is purely diagrammatic.

In reply to Dr. Patrick's question, the tenderness of the spines below the vertebral level of the disease is not the same at all levels. It is greater in the lower thoracic region than in the upper thoracic or in the cervical regions.

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1. Thomas, André: Le reflexe Pilomoteur, Paris, Masson et Cie, 1922.

2. Ceillier, A.: Para-osteo-arthropathies des paraplegiques, Paris, 1920. Ceillier and Mme. Déjerine: Rev. neurol. 1918, pp. 159, 207, 348; 1919, p. 399.

This is quite different from what occurs in malignant disease of the bone, where the tender spine corresponds to the vertebrae involved, but not to the segment level of the disease. For these reasons we have concluded that the cause of the tenderness of the spinous processes was different in the two affections. In the one it is a nerve root tenderness, the spine being sensitive because it is the one supplied by the affected nerve root or from the affected segment, a true bone tenderness being present. We have kept careful records of this tenderness and on going over them we found the surprising fact which I have described. In several instances we have been able to verify the correctness of our conclusions.

I do not know whether the contralateral tingling and paresthesia about which Dr. Spiller spoke are due to direct pressure on the spinothalamic tracts on the same side or to pressure from the other side. The mechanism is not clear to me and I have only recorded the facts as we obtained them from the study of our records.

In answer to Dr. Prince, I do not understand the physics of the process; theoretically, however, Dr. Prince is correct. I attempted to gain information on this subject from several physicists, but I received unsatisfactory replies. While they all said that the law of physics, as mentioned by Dr. Prince, would hold good, they added that it was perfectly possible with a movable fluid which protected the cord on all sides for the cord to move to the other side of the canal. The condition obtained that on one side of the cord was the resistance of bony wall, while on the other side was a water pad which was protecting the cord. Therefore, it would be possible to have symptoms from the pressure of the cord on the bony resistance.

SHALL WE DECOMPRESS FOR CHOKED DISK?*

B. SACHS, M.D.

NEW YORK

The importance of choked disk as a sign of intracranial disease is all the greater because in many instances it appears early, and in many others the diagnosis is uncertain until this sign does appear. Taken by itself, it is alarming, and the impulse among neurologists and neurosurgeons to do something in order to avert impending blindness is natural and excusable.

During the last twenty-nine years I have been in charge of a very active neurologic service, and during this period brain tumors and allied conditions have had my serious attention. If the tumor (a cyst, neoplasm or abscess) could be reached, a direct attack on the lesion was planned. Not infrequently the growth or abscess could not be localized accurately, but the choked disk, with the fear of impending amaurosis, had to be considered. Decompression was advised and performed many times in the hope of averting blindness, which was almost certain to set in long before the patient's life was in danger. Of late years I have had less and less faith in the efficacy of decompression. Personal impressions of many years had led to a firm belief that often decompression, pure and simple, did not effect what it promised. One neurosurgeon said that he would not perform a decompression for pontile tumors. Then I queried, Is it ever worth while?

So I requested one of my adjuncts, Dr. Wechsler, to whom the records on brain tumor had been entrusted for special study, to analyze these records with reference to decompression operations. One hundred and forty cases of brain tumor from the neurologic and neurosurgical clinics were studied. Many cases were excluded because of unsatisfactory or complicating conditions. Of these 140 cases, forty-five (32 per cent.) were completely unlocalized. Ninety-five (68 per cent.) during the period of examination were localized. Incidentally it may be of interest to note the occurrence or nonoccurrence of choked disk in relation to the site of the tumor.

The table shows that of nineteen cases of cerebellar tumor, choked disk was present in seventeen, and absent in only two. In tumors of the hypophysis, it was present in three and absent in twelve. In frontal lobe tumor it was present nine times and absent four times, whereas in temperosphenoidal tumors it was absent in one case and present in nine; and of eight angle tumors, it was present four times

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* Read at the Forty-Eighth Annual Meeting of the American Neurological Association, Washington, D. C., May, 1922.

and absent four times. Taking the entire list of ninety-five localized tumors, choked disk was present in sixty-four cases and absent in thirty-one.

The large percentage of nonlocalized tumors shows that large growths may develop in a silent area and not cause a single localizing sign until the growth invades a more distant part of the brain. This is particularly true of all frontal tumors. The psychic phenomena, the olfactory disturbances, the special forms of ataxia associated with frontal lobe neoplasms, often leave one in the lurch, and sensitiveness to percussion is not infrequently misleading. But when there is invasion of the parietal areas the symptoms become definite. As a result of this, the diagnosis of parietal tumor is sometimes made when the growth originates elsewhere.

CHOKED DISK IN VARIOUS INTRACRANIAL TUMORS

Site	Number of Cases	Choked Disk	No Choked Disk
Cerebellum	19	17	2
Hypophysis	15	3	12
Frontal lobe	13	9	4
Temperosphenoidal	10	9	1
Cerebello-pontile angle	8	4	4
Posterior fossa	4	3	1
Parieto-occipital	6	4	2
Right hemisphere	7	5	2
Left hemisphere	5	4	1
Third ventricle	2	2	..
Fourth ventricle	2	2	..
Lateral ventricle	1	1	..
Pontile	2	..	2
Pineal	1	1	..
Total	95	64	31

This very uncertainty as to the initial site of the tumor and the still greater uncertainty as to the extent of the growth, in many instances render the neurosurgical problem a most perplexing one. Though the localizing signs may be absent, the general symptoms, and above all, the choked disk demand attention.

In a series of thirty-eight cases decompression was performed for the relief of this special condition. In seven of these cases the site of the tumor remained wholly unknown. Of these thirty-eight cases, which were retained in the hospital and studied long enough to judge of the results, twenty-nine showed no recession. In four cases there was distinct improvement, so that the operation may have been considered satisfactory. Five showed slight recession. In five of the twenty-nine cases which showed no recession, optic atrophy resulted. In others, optic atrophy may have developed at later periods. There

may be some satisfaction if any vision is retained, but it does not prove that decompression promotes recession of choked disk.

Under these circumstances, there would appear to be strong corroboration of the impression that decompression operations, pure and simple, promise little—and let me say that it seems to matter little whether the decompression be of the ordinary subtemporal or suboccipital type—the suboccipital site having been chosen naturally when there was a suspicion of a cerebellar or cerebellopontile angle tumor. One is tempted to ask whether decompression operations really decompress, and whether or not in the presence of a large neoplasm intracranial conditions are improved by this dislocation of the intracranial contents.

Roentgen-ray studies frequently show enormous distortion of the ventricles in the presence of brain tumor; and no doubt intraventricular pressure has some, if not a great, effect on the development of choked disk. Does the opening in the skull and the dura better these ventricular conditions?

If we are not able as yet to answer these questions, we must at least give the facts due consideration. That decompression does in some instances bring about a favorable change in the intracranial relations is evident from the improvement that has been witnessed in many instances, so far as the intense headaches are concerned; and for the relief of this often distressing condition operative procedures are to be urged.

There is one other thought to which I wish to give expression. Those of us who are likely to be somewhat conservative are told that we should not have waited until the appearance of choked disk; that the patient had a better chance if operated on early. Were the results of brain tumor removal more satisfactory, I would be heartily in sympathy with this view. Once the choked disk has appeared, it may be asserted that the tumor is already of considerable size and difficult of removal. It is so often a question of weighing the great risk of operation against the uncertainties of diagnosis.

To make matters still more perplexing, choked disk does not necessarily indicate the presence of a neoplasm, especially in these days of encephalitic lesions; moreover, choked disk does sometimes recede spontaneously and recovery from this condition may ensue without surgical interference. Only recently I had a vivid experience of this kind with a boy, 9 years of age, who presented many of the symptoms of a cerebellar neoplasm, such as weakness of the right rectus externus, nystagmoid movements, slight right facial paralysis, adiadokokinesis of the left side, diminished knee reflexes and Achilles' jerks, slight rigidity of the neck, diminished hearing on the left side and a tendency to fall to the left. With these symptoms was associated bilateral papilledema of 5 diopters. The otologist, as well as the ophthalmologist who

examined him, felt that all the signs pointed to marked increase of intracranial pressure. There was no rise of temperature, the blood and spinal fluid Wassermann reactions were negative, the spinal fluid was under pressure and contained only one lymphocyte. My own conclusion, after a careful examination, was that while the symptoms pointed to cerebellar involvement, the findings were so unusual that it would be well to defer surgical interference until a satisfactory explanation could be found. The boy was in the hospital from Feb. 19, 1922, to March 13, 1922. On March 20, the eyes were examined by one of the capable ophthalmologists, Dr. Schlivek, who found an elevation of only 3 diopters; but he added that "in the macula of the right eye there is a beginning stellate figure. This indicates an old condition." After three weeks, the same oculist reported that "the eyes show evidence that the choked disk is receding; the elevation in the right is 1 diopter, in the left 2 diopters."

What the final diagnosis will be in this case I am not yet willing to state. The point that I wish to emphasize is that in some of these cases the choked disk may recede and go on to spontaneous recovery.

COMMENT

My own view is that the ordinary decompression operation, whether subtemporal or suboccipital, promises little for the relief of choked disk; in twenty-nine out of thirty-eight of our cases it was practically time and labor wasted. Instead of performing this operation, every effort should be made to attack the tumor itself and to remove the neoplasm, provided the patient's life can be spared.

I suspect that in many instances, the decompression operation has discouraged the patient, has made a further operation objectionable, and has often lessened the ardor of the surgeon to get at the growth itself. If we are to go on with the decompression operation, for the relief of symptoms only, it must be made a harmless procedure; harmless as to life and harmless so far as the later successful removal of the brain tumor is concerned.

DISCUSSION

Dr. Hugh T. Patrick, Chicago: I think that a vital point has been omitted in Dr. Sachs' report; namely, the state of vision. Whether one operates for choked disk should depend to a certain extent on the visual acuity of the patient. In many cases optic atrophy has begun and advanced considerably before any material recession in the choked disk.

Dr. Ernest Sachs, St. Louis: The point that Dr. Patrick made is an important one: that if you operate when optic atrophy is developing decompression may not aid at all.

In the cases that Dr. Sachs has cited, it has been a common experience to find that choked disk rarely is present in pituitary tumors, and in some of the other groups of cases, of which he spoke, a similar thing has been known.

In his book, Dr. Cushing has emphasized the fact that in acoustic tumors, until the cerebrospinal circulation is interfered with, often there may not be any choked disk. My experience is absolutely at variance with the figures that Dr. Sachs has given. If decompression is performed at the proper place and while the vision is still fairly good, the choked disk definitely subsides in many instances, and vision is improved and retained.

I do not want to give the impression that I advocate decompression if there is any possibility of removing the tumor. I perform fewer decompressions now than I did several years ago, but I cannot agree with Dr. Sachs' statement that decompression does not make a choked disk subside if it is performed at the proper place and before optic atrophy is too far advanced.

Dr. Harvey Cushing, Boston: I think that Dr. Sachs is justified in his interpretation of his own experience. There are many different ways of doing decompression operations and different things that one may expect from them. It is purely a palliative measure and not a "cure all." Nor does it always accomplish its purpose, but it saves a great deal of suffering, and saves vision in a great many cases for a short time; and that is about as much as can be expected of it.

I am sure all those who have had much neurosurgical experience have seen many cases in which discomfort has been lessened and vision improved. If we could accomplish this with a drug it would seem miraculous. Our methods of tumor localization are improving greatly. We hope ventricular radiography will give us additional aid. Consequently, we resort less often than formerly to simple palliative measures. I shall give an example of relief obtained by palliation. A naval cadet was referred to me last year by Dr. Wilmer with a rapidly advancing choked disk of about 6 diopters, which threatened loss of vision. Localizing symptoms were inconspicuous, but they suggested a cerebellar lesion. A suboccipital exploration was performed, but no lesion was found. The patient made an immediate recovery; the choked disk subsided accompanied by normal vision, and all other symptoms disappeared. Our conclusion was that we had made a mistake in diagnosis, and the case was recorded as a "tumor suspect," probably chronic arachnoiditis. Possibly a ventriculogram might have shown a tumor, but I have grave doubts of this.

The young man returned to the Academy and later was sent to sea on active duty, remaining free of symptoms. However, several months later, while exercising in the gymnasium in Annapolis, he had a return of symptoms. He was sent to Baltimore for further operation. Dr. Dandy reexplored and found a cerebellar glioma, which he attempted to remove in its entirety, without success. If I had been able to identify the tumor at the first session I might have successfully removed it by a lobectomy, but I found no evidence of a growth and would not have been justified in exploring for it, and if I had done so, the young man would not have enjoyed the long period of relief afforded by the decompression alone.

A subtemporal decompression would not have accomplished this result, and I am not sure from what Dr. Sachs has said that he appreciates that in the presence of an internal hydrocephalus a subtemporal decompression is not of much value. But it is true that decompressive measures are being used less often as our ability to localize tumors improves.

Dr. Sachs, in closing: This method has not advanced very far because Dr. Cushing has acknowledged that less decompression is being performed. If the diagnostic ability is developed to a greater extent, less time will be spent on decompression operation for the relief of choked disk. Decompression is never advised if there is the slightest suspicion of atrophy of the optic nerve.

RESULTS OF THE REMOVAL OF TUMORS OF THE SPINAL CORD*

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ROCHESTER, MINN.

Results following the surgical treatment of tumors of the spinal cord depend on the duration of symptoms and on the position, level and type of tumor. The histories vary but are suggestive and give the first clue to the diagnosis. The onset of symptoms is gradual; sensory disturbance is usually the first, that is, paresthesia or anesthesia, accompanied by motor disturbances. The condition may improve temporarily; but the symptoms gradually progress to a loss of sensibility and motor function, in conjunction with exaggerated reflexes below the cord segment involved.

About thirty-five years have elapsed since the first tumor of the spinal cord was removed by Horsley. During this short time, many tumors of the spinal cord have been removed; but many have also been overlooked because a definite level of loss of motor power and sensibility was not present or the exact history of motor or sensory loss that was expected was not given.

In our experience, pain in the spine while the patient is lying down, exaggerated by coughing, sneezing, jarring and bending, and often relieved by getting up and walking around, is an early symptom of intradural extramedullary tumor, generally situated in the vicinity of the cauda equina. If pain persists along the sciatic nerves for years without yielding to treatment for sciatica, the possibility of tumor of the cord must be considered. In 1921, we removed four tumors of the spinal cord from patients who complained of very little except the pain herein described.

Spinal puncture is of value in the diagnosis, inasmuch as the presence of yellow fluid, that is, fluid containing xanthochromia, helps to confirm the diagnosis of tumor of the spinal cord. However, it does not differentiate extramedullary and intramedullary tumors. A dry tap in the fourth lumbar space, while fluid is obtained at a higher level, is also of value. The cisterna magna puncture in conjunction with spinal puncture is a valuable aid in confirming the presence or absence of obstruction in the canal, which most often is due to tumor of the spinal cord.

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* From the Section on Neurologic Surgery, Mayo Clinic.

* Read before the Section on Surgery, General and Abdominal, at the Seventy-Third Annual Session of the American Medical Association, St. Louis, May, 1922.

The rate of progress depends on the position and type of the tumor. Soft neoplasms and neoplasms of the intramedullary type usually progress slowly, while hard, encapsulated tumors produce considerable pressure and cause marked paralysis in a few months, the damage to the cord being much more permanent than that caused by soft tumors. Tumors pressing the cord dorsally cause sensory disturbances before

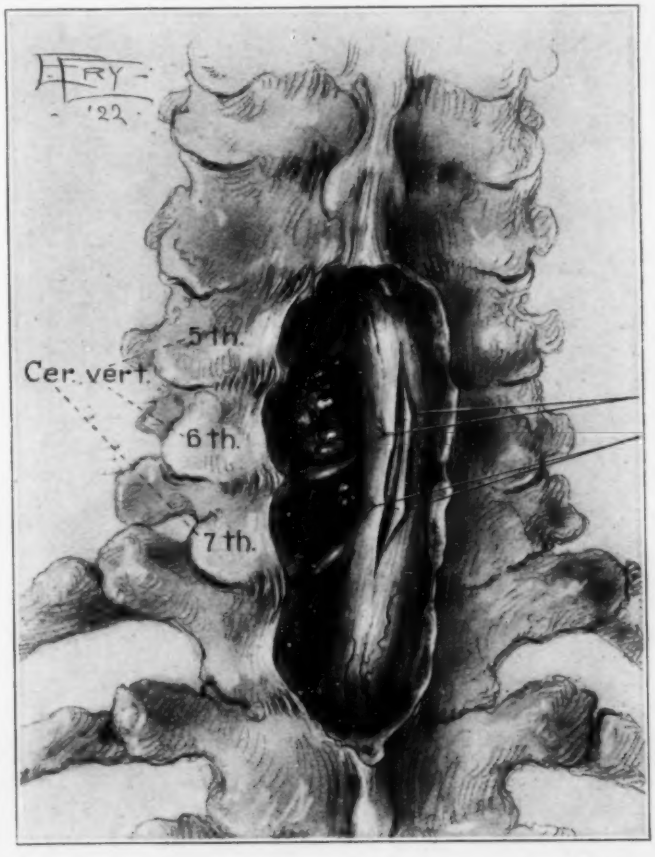

Fig. 1.—Fibrochondroma situated anterolaterally to the cervical cord. This illustration and Figures 2, 3 and 4 represent extradural tumors of the spinal cord.

motor; those situated laterally or anteriorly are more likely to produce Brown-Séquard's syndrome, with motor disturbances before sensory. Tumors of the cervical and dorsal cord cause symptoms earlier than those of the lumbar cord; those arising from the vertebrae or from the meninges, extradural or intradural but extramedullary, produce pressure on the cord without invading it, while those arising within the cord

itself produce destruction of the medullary portion and later destruction of the medullated fibers. Tumors of the spinal cord may occur in any part of the spinal canal or spinal cord; most occur in the thoracic region, fewer in the cervicodorsal, and fewer still in the dorsolumbar.

TYPE OF TUMOR

The character of tumors of the spinal cord depends directly on their origin; those arising from the vertebrae and from the tissues of the spinal canal are bony, cartilaginous or fascial; those arising from the

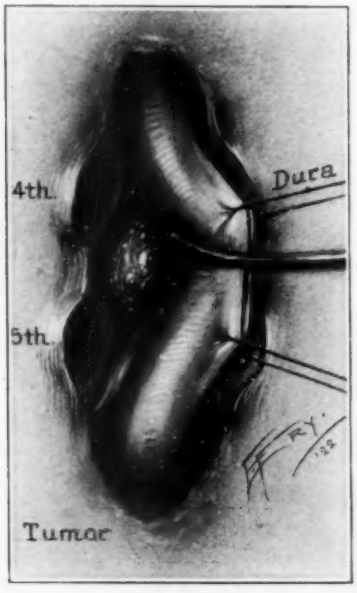

Fig. 2.—Fibrochondroma situated anteriorly to the cord, opposite the fourth and fifth lumbar vertebrae.

meninges are endotheliomas, fibromas, psammomas, and so forth. Such tumors, as a rule, are not very large, are slow growing, and are rarely malignant; their early removal favors ultimate cure.

Tumors of the cord itself are usually gliomatous, and arise around the central canal; some degenerate and become cystic, others remain firm and solid. Ependymal gliomas arise from the conus and extend downward through the canal of the lumbar region, and occasionally to the sacral region. Most ependymal gliomas in the lumbosacral region are encapsulated and not adherent to the lumbosacral roots, but may be situated between them and fill the spinal canal.

TABLE 1.—FINDINGS IN LESIONS OF THE SPINAL CORD

	Patients	Males	Females	Average Age, Years	Oldest, Years	Youngest, Years	Duration of Symptoms: Average, Months	Duration of Symptoms: Shortest, Months	Duration of Symptoms: Longest, Months	Presence of Root Pain: Patients	Presence of Root Pain: Per Cent.
Tumors: Extradural	14	10	4	42.5	64	16	28	1	132	8	57
Intradural but extramedullary	30	16	14	44.5	61	20	45	2	168	20	66
Intramedullary	31	19	12	44.0	63	12	45	4	156	22	71
No tumor found; meningomyelitis (?)	27	14	13	33.0	50	16	40	3	156	13	54
Varicose veins	3	2	1	27.0	30	22	79	10	204	1	33
Echinococcus cyst	1	..	1	44.0	..	..	7	..	...	1	100
Tuberculoma	2	..	2	45.0	59	32	15	12	18	1	50
Gumma	2	2	..	29.0	34	25	29	25	34	2	100
Cerebellospinal tumors	2	1	1	25.0	48	2.5	25	2	48	..	..
Total	112	64	48								

TABLE 2.—FINDINGS IN LESIONS OF THE SPINAL CORD

		Paralysis: Motor			Paralysis: Sensory			Paralysis: Bladder			Paralysis: Rectal			Spinal Fluid Findings				
	Patients	Absent	Partial	Complete	Absent	Par. tial	Complete	Absent	Partial	Complete	Absent	Partial	Complete	Spinal Punctures	Dry Tap	Xanthochromia	Nonne Positive	Average Cell Count
Tumors: Extradural	14	3	4	7	2	6	6	4	4	6	4	4	6	11	1	1	6	6
Intradural but extramedullary	30	3	18	9	3	17	10	4	15	11	4	15	11	21	..	5	11	3
Intramedullary	31	..	24	7	..	22	9	7	14	10	7	9	15	23	1	7	12	5
No tumor found; meningomyelitis(?)	27	..	23	4	1	18	8	3	21	3	2	20	5	18	..	..	3	4
Varicose veins	3	..	3	..	..	3	..	..	3	..	..	3	..	1	..	..	..	5
Echinococcus cyst	1	..	1	..	..	1	..	..	1	..	..	1	..	1	..	..	..	1
Tuberculoma	2	..	1	1	..	1	1	..	1	1	..	1	1	1	..	..	..	2
Gumma	2	..	..	2	..	..	2	..	..	2	..	..	2	2	..	..	..	1
Cerebellospinal tumors	2	1	1	..	2	..	..	2	..	..	2	..	..	1	..	..	1	1
Total	112	7	75	30	8	68	36	20	59	33	19	53	40	89	2	13	33	

MAYO CLINIC SERIES

The records of the Mayo Clinic from January, 1910, to April, 1922, show that 112 patients were operated on for tumor of the spinal cord. Fifteen laminectomies were performed from 1910 to 1916, in six of which tumors were not found. From 1916 to April 1, 1922, ninety-seven patients were operated on for tumor of the cord, in seventy-six of which neoplasms were found; in twenty-one the findings were negative except for inflammatory processes. In four of the twenty-one, later examination revealed the presence of tumors; two of these were intradural but extramedullary, and above the level explored; both were verified at necropsy. One of the patients had two endotheliomatous tumors, about 15 cm. apart. Two had developed huge tumors, arising

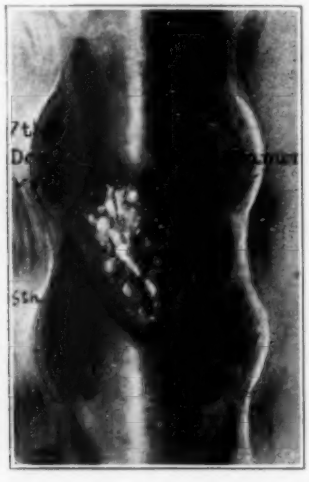

Fig. 3.—Angioneuroma situated dorsally to the spinal cord, opposite the sixth dorsal vertebra.

from the sacrum, posterior to the rectum; these were not palpable by rectal examination before laminectomy. Sixty-four of the patients were men and forty-eight were women. For detailed study, we have divided the patients into nine groups.

Group 1 consists of fourteen patients with extradural tumors.

Group 2 consists of thirty patients with intradural but extramedullary tumors.

Group 3 is composed of thirty-one patients with intramedullary tumors.

Group 4 consists of twenty-seven patients in whom no tumor was found. A few had chronic meningomyelitis, and in four tumors were found at a later date.

TABLE 3.—Findings in Lesions of the Spinal Cord

	Patients	Level of Tumors: Cervical	Dorsal	Lumbar	Sacral	Tumors Removed	Type of Tumor Removed: Lipoma	Fibroma	Angioneuroma	Neurofibrosarcoma	Fibrochondroma	Glioma	Hemangioma	Psammoma	Neurofibroma	Endothelioma	Echinococcus Cyst	Inflammatory Tumor	Tumors Partially Removed	Type of Tumor Partially Removed: Gliosarcoma	Neurofibroma	Sarcoma	Degenerating Neoplasm	Glioma	Endothelioma	Inflammatory Tumor	Exploration
Tumors: Extradural	14	3	8	3	..	10	2	1	1	2	4	..	..	..	..	..	..	..	4	2	1	1	..	..	..	..	..
Intradural but extramedullary	30	7	19	3	1	29	..	3	..	..	..	2	1	12	7	3	..	1	..	..	..	..	..	..	..	..	1
Intramedullary	31	6	25	..	..	3	..	..	..	..	..	2	..	..	..	1	..	..	18	..	1	1	2	13	..	1	10
No tumor found; meningomyelitis (?)*	27	..	24	..	2‡	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Varicose veins	3	..	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3
Echinococcus cyst	1	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Tuberculoma	2	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
Gumma	2	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	2	..
Cerebellospinal tumors	2	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	1	1	..	..
Total	112	18	59	9	3	43	..	..	..	..	..	..	..	..	..	..	..	..	26	..	..	..	..	..	..	..	16

* Four tumors were found at a later date, two were endotheliomas and two Mitteldorph tumors.
† Found at necropsy.
‡ Palpable on pelvic and rectal examination after operation.

Group 5 consists of three patients with angiomas of the spinal cord (varicose veins).

Group 6 consists of one patient with an echinococcus cyst of the cord, who had been operated on previously for echinococcus cysts of the lung and the liver.

Group 7 is composed of two patients with tuberculoma of the cord, one of whom had an extensive tuberculoma on the anterior and lateral surfaces of the cervicodorsal cord, associated with miliary tuberculosis. These findings were verified at necropsy. The other patient had a unilateral inflammatory lesion of the cauda equina, resembling tuberculoma without neoplastic cells. The condition had not progressed farther since 1917.

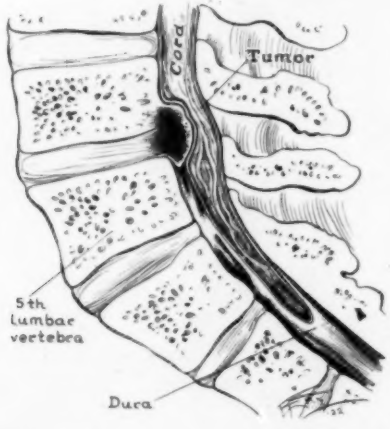

Fig. 4.—Sagittal section of region of fourth and fifth lumbar vertebrae in the case shown in Figure 2.

Group 8 is made up of two patients with gumma of the cord, both of whom gave histories positive for syphilis and presented definite levels of paralysis. In one the meninges were thickened and adherent to the cord in one large mass for 4 cm.; the other, who gave a short history, approximately six months, presented very similar findings except that the dura could be separated from the soft inflammatory mass. We were able to remove part of the inflammatory mass at operation; the wound was closed and the dura left open. The patient recovered his motor power and sensation, and is apparently free from symptoms. It is also interesting to note that one of the patients of Group 5, in whom an angioma was found, gave a positive history of syphilis.

Group 9 consists of two patients with cerebellospinal tumors; one of them was 48 years of age, and the other 2½ years. Both had large

vermis tumors, extending through the foramen magnum into the spinal canal. Only a partial removal was possible, and both patients died soon after operation.

Duration of Symptoms.—The average duration of symptoms in Group 1 was twenty-eight months; in Group 2, forty-five months; in

Fig. 5.—Psammoma. This illustration and Figures 6, 7 and 8 represent intradural but extramedullary tumors of the spinal cord.

Fig. 6.—Encapsulated intramedullary endothelioma removed from the dorsolumbar cord, extending upward from the conus.

Group 3, forty-five months, and in Group 4, forty months. The other groups are so small that a definite average was not obtained.

Root Pain.—Root pain was present in eight patients (57 per cent.) of Group 1; in twenty (66 per cent.) of Group 2; in twenty-two (71 per cent.) of Group 3, and in thirteen (54 per cent.) of Group 4. In Groups 5, 6, 7, 8 and 9, four patients (44 per cent.) had root pain.

TABLE 4.—Findings in Lesions of the Spinal Cord

		Hospital Convalescence															Died After Leaving Hospital						
					Cause of Death														Cause of Death				
	Patients	Died	Average Time in Hospital, Days	Pneumonia	Meningitis	Myocardial Degeneration	Uremia	Pyelonephritis	Surgical Shock Due to Hemorrhage	Embolism	Septicemia	Fat Embolism	Intracranial Pressure	Internal Hydrocephalus	Miliary Tuberculosis	Unknown	Average Time Since Operation, Months		Morphinism	Meningitis	Septicemia	Pyelonephritis	Unknown
Tumors: Extradural	14	2	26	1	1	..	..	..	..	..	..	..	..	..	..	..	1	5	..	..	..	..	1
Intradural but extramedullary	20	4	25	..	1	1	1	1	..	..	..	..	..	..	..	..	2	22	1	..	..	..	1
Intramedullary	31	3	60	..	..	..	..	..	1	1	1	..	..	..	..	..	8	17	..	1	1	1	5
No tumor found; meningomyelitis (?)	27	5	21	..	1	..	..	..	..	2	..	1	..	..	..	1	5	43	..	..	..	1	4
Varicose veins	3	..	21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Echinococcus cyst	1	..	21	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..
Tuberculoma	2	1	13	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gumma	2	..	17	..	..	..	..	..	..	..	..	..	1	1	..	..	1	48	..	..	..	..	1
Cerebellospinal tumors	2	2	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 1 gives the number of patients with and without motor and sensory paralysis of the bladder and rectal areas.

Spinal Fluid Findings.—These findings (Tables 1, 2, 3 and 4) are of interest, as frequency of xanthochromia, high cell count, globulin and a positive Wassermann reaction are shown. In the 112 patients operated on, eighty-nine spinal punctures were performed. In thirteen instances,

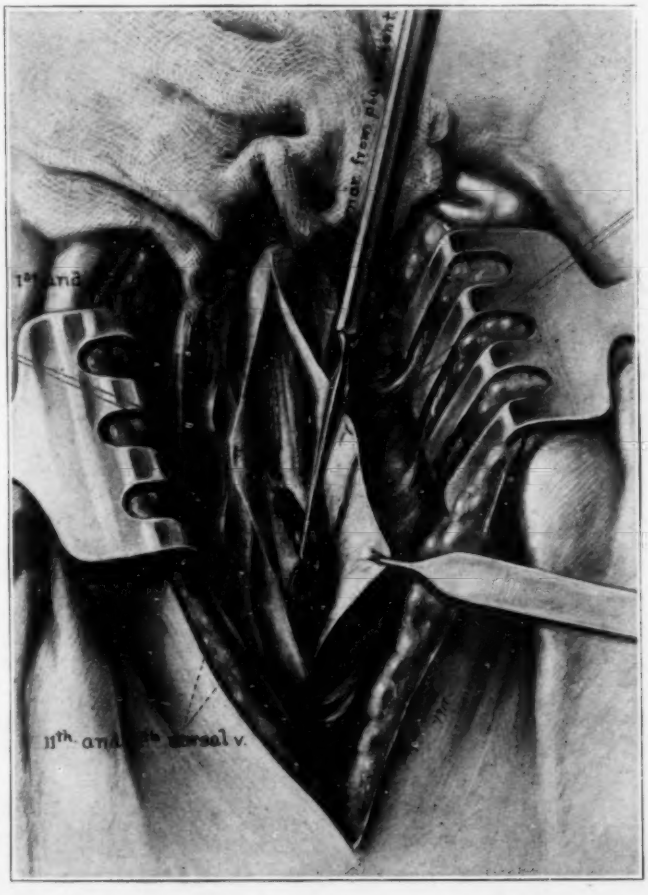

Fig. 7.—Angioma or varicose veins of the cord.

xanthochromia was found in the spinal fluid; in thirty-two the Nonne test for globulin was positive, and in those in which a cell count was made the average count was 3, and the highest count was 18. The Wassermann reaction on the spinal fluid was negative in every instance, even though three patients gave histories positive for syphilis.

Location of Tumor.—In fifty-nine patients, the tumor was in the dorsal region; occasionally, however, it extended into the cervical and

TABLE 5.—End-Results in Treatment of Lesions of the Spinal Cord

	Patients	Living	Average Length of Postoperative Life, Months	Well and at Work	Improved and Working Some	Improved but Not at Work	Improved for an Average of Five Months	Helpless	Not Traced
Tumors: Extradural	14	11	37.5	5	1	3	..	..	2
Intradural but extramedullary	30	24	32.0	13	2	3	..	1	5
Intramedullary	31	22	35.0	1	3	9	..	4	5
No tumor found; meningomyelitis (?)	27	17	34.0	2	1	1	2	9	2
Varicose veins	3	2	75.0	..	..	1	..	..	1
Echinococcus cyst	1	1	21.0	..	..	1	..	..	..
Tuberculoma	2	1	54.0	..	..	1	..	..	..
Gumma	2	1	8.0	1	..	..	..	..	..
Cerebellospinal tumors	2	..	....	..	..	..	..	..	..
Total	112	79	....	22	7	19	2	14	15

Neoplasm found in 85 patients (76 per cent.) of 112 in whom laminectomy for cord tumor was performed.
43 tumors removed completely = 51 per cent of tumors found are removable.
26 tumors partially removed = 30 per cent. of tumors found are partially removable.
22 patients well and working.
7 improved and working some.
19 improved and not working.
48 total improved = {43 per cent. of 112 in whom laminectomy was performed. / 56 per cent. of 85 in whom tumors were found.}

the lumbar areas, but the principal part was in the dorsal region. In eighteen patients, the tumor was in the cervical region, in nine in the lumbar region, and in three in the sacral region. In twenty-three a tumor was not found, or the symptoms were due to an inflammatory process.

Removal of Tumor.—Tumors were removed completely from forty-three patients (39 per cent. of the entire series); tumors were removed partially from twenty-six (23 per cent.).

Fig. 8.—Gumma of the spinal cord and meninges.

End-Results.—Of the 112 patients operated on for tumor of the spinal cord during the period of our study (twelve years), seventy-nine are alive. Twenty-two of the living have recovered completely and are doing their regular work; seven have improved sufficiently to do a little work, and twenty-one have improved, but are unable to work; fourteen are helpless. Fifteen patients did not reply to our letter of inquiry. It is fair to assume that a few of these have improved, since patients who have not improved are more likely to reply than patients who are well and free from symptoms.

Operation.—We employ no special technic in laminectomies for the removal of tumors of the spinal cord, aside from precautionary

measures against traumatizing the cord or permitting hemorrhage within the dura. The spines and laminae are removed; the muscles are closed in two planes with interrupted and continuous sutures of catgut, and the skin is closed by a subcuticular stitch of catgut, besides a dermal suture. If the tumor is in the cervical region, a unilateral laminectomy is performed, with the removal of the opposite lamina and the spine over the tumor. This precaution is taken because one patient had a recurrence of symptoms owing to slipping of the bodies of the cervical vertebrae, causing traction and pressure on the cervical

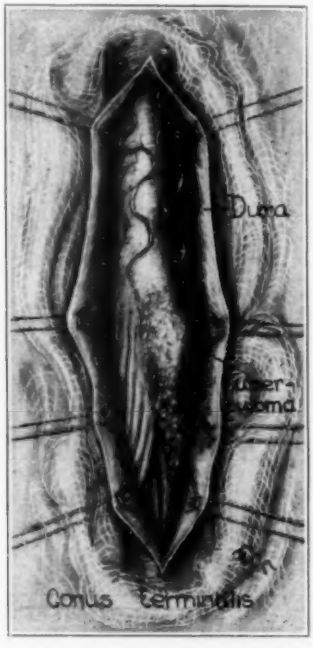

Fig. 9.—Tuberculoma (?) of the cauda equina, unilateral lesion.

cord and resulting in paralysis. While we prefer the one-stage laminectomy, we have found it necessary to perform a two-stage operation in seven of our cases, and a three-stage operation in one, because of the extensiveness of the lesions. As a rule, we remove three spines and laminae before we open the dura; five or six can be removed with little difficulty. Ependymal gliomas of the cauda equina usually extend from the eleventh dorsal to the first or second sacral vertebra, and in such cases trouble will be encountered if too much is attempted at one operation. Otherwise, the one-stage operation is very satisfactory, especially to the patient, and there is danger of infection in opening a recent wound for a second operation.

Ether anesthesia has been employed in the greater number of cases; however, we have found paravertebral anesthesia very satisfactory in obese patients and in patients who are poor surgical risks. It is necessary to apply a 1 per cent. solution of procain to the dura, as it is exposed during laminectomy, since it is not desensitized in the paravertebral anesthesia by procain. A few drops of 1 per cent. solution of procain can be injected into the dural canal above the tumor without danger. Intraspinal anesthesia by procain can also be used in low

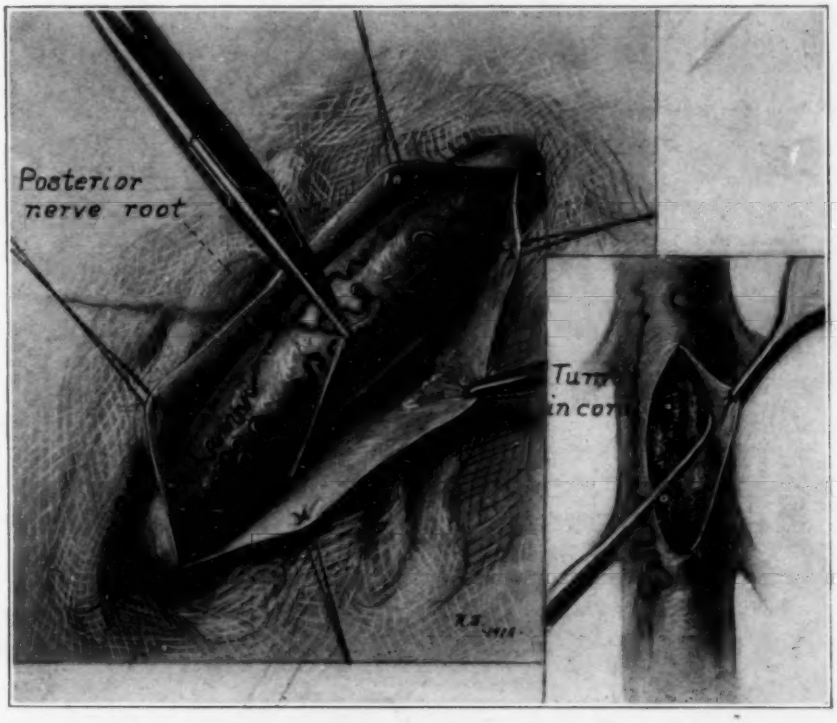

Fig. 10.—Intramedullary degenerating glioma of the dorsal cord.

laminectomies of the lumbar and sacral regions, but should be used cautiously, if at all, in middle dorsal or upper dorsal lesions.

Postoperative Care.—The care of patients after laminectomy differs little from general surgical care. We prefer to keep the patient on his abdomen on three or four soft pillows, with the head slightly lower than the operative field, for three or four days, besides avoiding undue pressure on the bony prominences. He is then permitted to turn on his side, and after ten or twelve days to lie on his back. About the fourteenth day he may sit up in a chair. We have found that he is more comfortable in the prone position, that the wound heals more

rapidly, and there is less danger of drainage of cerebrospinal fluid, especially in cases of intramedullary tumors in which the dura is left open. Provided the patient has not been catheterized previously, the bladder is allowed to overflow. If cystitis is present and the patient has been catheterized previously, a retention catheter is inserted prior to opera-

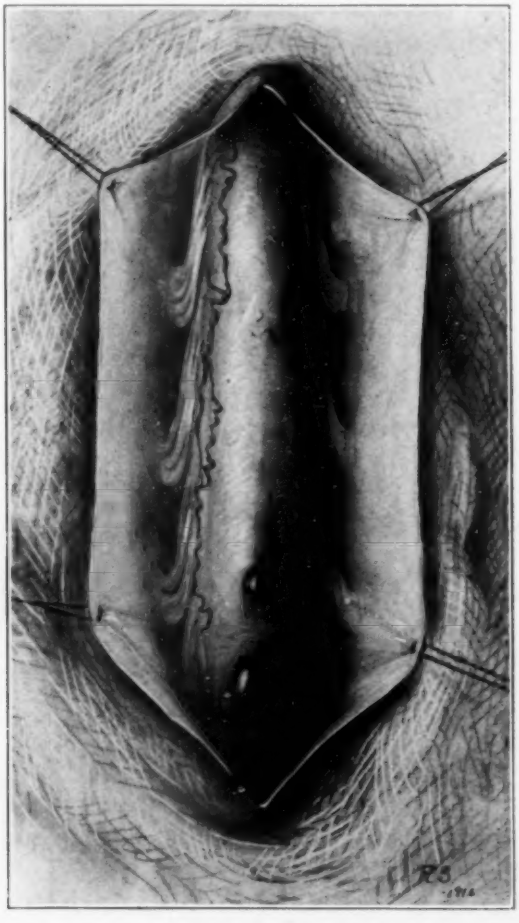

Fig. 11.—Tumor shown in Figure 10, extending down into the conus.

tion, and is changed about once a week. The bladder is lavaged daily with a 2 per cent. solution of boric acid, and about one-half ounce (15 c.c.) of 10 per cent. solution of argyrol is introduced and allowed to remain in the bladder for one-half hour. If there is any evidence of pyelitis, acid sodium phosphate and hexamethylenamin, 7 grains (4.5 gm.) of each, three times a day, are administered. This is followed by a week of rest, and a second course of medication.

Convalescence.—Recovery depends on the duration of symptoms. If the tumor has been removed without trauma, a patient with a duration of symptoms of one year or less may be expected to recover completely; one with a duration of symptoms of not more than three years, to improve markedly. Recovery is more complete following the removal of soft tumors than hard, nodular ones; and, if the same degree of paralysis exists, recovery is more complete if the tumors are in the caudal or lumbar regions, than if in the dorsal or cervical regions. Extradural and intradural but extramedullary tumors can usually be removed completely with very little difficulty, but it is difficult to remove intramedullary tumors. In our group of intramedullary tumors, one endothelioma only could be removed completely. This tumor arose apparently from the pia mater and extended into the cord. We have attempted partially to remove several intramedullary tumors, and sometimes we have split the cord dorsally and permitted the tumor to extrude. The results have been twofold: some patients have been made worse by attempted removal; others have improved for a time and then developed recurrence of symptoms. As a whole, the results of removal of intramedullary tumors are unsatisfactory, and we believe that unless the tumor is very close to the dorsal surface of the cord less damage will be done and more temporary relief afforded the patient by laminectomy and incising the cord dorsally. The administration of radium may prove of some value in this group. One of the patients who were treated by radium apparently improved; another improved for one month following partial removal of an intramedullary tumor and then failed until he was paralyzed completely. If radium is used, it should be screened very carefully and not placed directly on the cord.

SUMMARY

In a series of 112 laminectomies, tumors were found in eighty-five (76 per cent.). Forty-three of the tumors (51 per cent.) were removed completely, twenty-six (30 per cent.) were removed partially, and sixteen were not removed. In twenty-seven cases no tumor could be found at operation; in four of these, tumors were demonstrated later. Seventy-nine patients are living; twenty-two are perfectly well and at work. Seven are improved and doing a little work; twenty-one are improved but not at work, and fourteen are helpless. Fifteen were not traced. Seventeen died in the hospital, and seventeen died subsequently at home, with an average time of two years between operation and death.

Tumor of the spinal cord is more common than is realized; many are overlooked or are found late. The best results are obtained by early operation.

DISCUSSION

Dr. Charles H. Frazier, Philadelphia: I have recently made a very critical analysis of fourteen consecutive laminectomies performed for tumors. The diagnosis is the most important. The surgical problems present relatively few difficulties. Dr. Adson has dwelt very properly on the question of pain as an important diagnostic feature. Not only was pain present in all but one of my cases, but it was a constant symptom in all and was referred to a constant location in all from the time of onset until the time of operation. Pain was present in one half of the cases for three years prior to the onset of motor disability and in at least one third of the remaining cases for two years prior to motor disability. So for these various reasons we lay greater emphasis on pain as a diagnostic feature. In the development of the syndrome I think you will find that, while pain is the first symptom in almost all cases, paresthesia is almost invariably the second symptom. Pain, being a root symptom, is on the side of the lesion, and paresthesia, a cord symptom, may be homolateral or contralateral. Motor impairment has come on comparatively late in my series; it has not been particularly important so far as diagnosis was concerned. It was the principal reason for surgical consultation, which was precipitated because, while the patient had been disturbed by pain and paresthesias, it was not until paralysis developed that surgical assistance was sought. With reference to segmental diagnosis we have placed emphasis on the following signs as of importance in their relative order: the level of sensory loss or impairment; the point to which the pain was referred; the loss of a given reflex; the sympathetic ocular phenomena, which always imply tumor in the lower cervical or upper thoracic region, and lastly muscular atrophy. In twelve of these fourteen cases, we found tumors which were distinctly operable; that is to say, they were localizable, definitely encapsulated and quite accessible, and they presented no great operative difficulties. Of the two exceptions, one was a metastatic carcinoma, involving the vertebral bodies, and the second a large, and, as I thought, an inoperable tumor of the cauda equina. There are two practical points in the surgical aspects of spinal tumors: (1) adequate exposure and (2) prevention of recurrence. In probably forty-nine out of fifty cases in which a mistake has been made the opening was too low rather than too high; to avoid this mistake we have adopted this rule: we select as the lower limit of the opening the spinal process opposite the segment representing the highest level of sensory loss or impairment. In this series of fourteen cases the tumor was exposed in every instance. In two cases, the tumor was only partly exposed by the laminectomy opening as originally planned, and in one of these the tumor extended within the cranial cavity. The second point of importance is the avoidance of recurrence. Extramedullary tumors take their origin invariably from the meninges and almost invariably from the lateral aspect of the spinal canal, and to avoid recurrences we must remove not only the tumor but also that portion of the dura to which the tumor is attached.

Dr. Ernest Sachs, St. Louis: Spinal cord tumors are not rare. Every case of what has heretofore been called transverse myelitis should be potentially considered as a tumor until proved otherwise. That will necessitate a considerable number of negative explorations, but a patient with a transverse lesion of the cord, unless some other etiologic factor has been found, has not been given a fair chance unless every method of diagnosis has been exhausted. A point emphasized by Dr. Adson and by Dr. Frazier, I would not agree with. In my experience with fifty cases, the first symptom was not pain. Very frequently it was paresthesia. Possibly because I live in Missouri, a large

number of these cases had been treated for a considerable time by various types of "adjustment." I know of nothing that is more discouraging than to have a negative exploration, and any method that will help reduce the number of negative explorations should be welcome. I have welcomed the work of Dr. Ayer, of Boston—his combined cistern puncture, which some of us thought rather dangerous, though it has not been so in his hands. Dr. Ayer has shown that if a lumbar puncture is done, and then the jugular veins are compressed, if there is a spinal block the cerebrospinal fluid in the tube connected with the needle will not rise. At least in one case, this method has prevented me from doing an exploration. I think we should keep this method in mind and make use of it and in that way, perhaps, reduce the number of negative explorations.

Dr. A. W. Adson, Rochester, Minn.: Pain is an important sign, but it is not absolutely diagnostic, as many patients have spinal cord tumors without the presence of root pain as a symptom. Puncture of the cisterna magna in conjunction with the spinal puncture is of some value. It is a spectacular procedure when one finds the pressure is greater in the cisterna magna than in the spinal canal, but this does not locate the tumor, and occasionally may give misleading information when adhesions are present between the arachnoid, pia mater, and the dura.

DYSTONIA MUSCULORUM DEFORMANS

WITH ESPECIAL REFERENCE TO A MYOSTATIC FORM AND THE OCCURRENCE OF DECEREBRATE RIGIDITY PHENOMENA. A STUDY OF SIX CASES *

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Dystonia musculorum deformans is not an uncommon disorder. It is well known for its kinetic phenomena, and most, if not all, of the case reports consist of analysis of the peculiar movements which characterize the clinical syndrome. Thus far spontaneous abnormal involuntary movements, torsion spasms, disturbances in tonus and possibly a racial peculiarity have come to be looked on as the criteria for the diagnosis of the bizarre entity. This clinical conception of the disorder, originally formulated by Ziehen and Oppenheim and so closely followed by subsequent observers, stresses only the hyperkinetic phenomena. But we have found cases in which these phenomena are present only to a slight extent or almost entirely absent, and yet we believe that they form part of the disease.

It is the object in this paper, besides recording six hitherto unreported cases of dystonia musculorum deformans with atypical and unusual features, to call attention to the existence of a myostatic variant of the disorder. But far from attempting to create a new clinical entity, we wish to correlate it with the well-known syndrome. This myostatic or postural variant is indeed a part of the disorder and always coexists with the kinetic disturbance of which it is only a complement. It is, in other words, a fleeting postural phase, observed between the waves of movement, become permanent. The occurrence of large and small fragments of decerebrate rigidity in typical cases of dystonia, to which we wish to call especial attention, further emphasizes the postural or myostatic disturbance in the condition. But, whereas in most cases the kinetic disturbance obscures or overshadows the postural element, there are some in which the latter is plainly evident and a few others in which it is dominant to such an extent that

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one begins to doubt whether the pictures are part of the same syndrome. It is our conviction that they are. The following case reports and their discussion will illustrate these points.

REPORT OF CASES

CASE 1.—*A case of dystonia musculorum deformans of the kinetic type beginning in the right hand and, up to the present, involving the musculature of both upper extremities, neck and head, with a fragment of decerebrate rigidity phenomena.*

Fig. 1.—A case of dystonia illustrating segmental involvement and a fragment of decerebrate rigidity limited to the right upper extremity.

History.—B. M., a boy, aged 15 years, born in the United States, a Jew of Russian parentage, about three and one-half years ago (1918) noticed difficulty in using his right hand, especially in writing. Soon after it was observed that his left upper extremity was held in a peculiar position, namely, flexed at the shoulder and elbow and adducted. About eighteen months after the onset, the patient's head and body began to bend over to the left side. During the course of his illness there gradually developed peculiar defensive movements of his left upper extremity, uncontrollable movements of the head and turning movements of his body.

Physical Examination.—The gait was normal. There was a marked involuntary torsion spasm involving the musculature of the head, neck, chest and left upper extremity. The head was rotated and markedly tilted to the left, the chin almost resting on the left shoulder. On extending the right upper extremity, the hand was turned with the palm outward, that is, overpronated, and the index finger was hyperextended. This constitutes a fragment of decerebrate rigidity, the so-called pronator sign of Wilson (Fig. 1). There was a coarse rhythmic tremor of the extended hand. While these movements appeared to come on in rhythmic waves, they were practically continuous in one part or another.

The spontaneous movements of the left upper extremity consisted of protraction of the arm together with flexion of the forearm; this movement was very similar to that assumed in defending one's face. In the upper extremities the dystonic spasm was revealed in an alternating hypertonia and hypotonia. It is curious to note that walking on all fours was accomplished much better than the motor disturbances of the upper extremities would seem to permit. Further neurologic examination was negative.

Discussion.—The disease began in one upper extremity, which is rather unusual. Other writers, especially Hunt,[1] have called attention to the frequency with which the disease begins in the lower extremity. This patient also shows an exquisite fragment of decerebrate rigidity in the right upper extremity, although the picture is mainly of the myokinetic variety. Finally, the movements are thus far limited to the head and neck, upper extremities and upper part of the trunk. It is quite possible, in view of the comparatively short duration of the illness, that it will extend downward and involve the rest of the trunk and lower extremities; but for the present the disease has assumed a segmental character. Attention is called to this distribution because a segmental delimitation has previously been pointed out in striatal diseases, especially in paralysis agitans.

CASE 2.—*A case of dystonia musculorum deformans of the kinetic type with the occurrence of both fragmentary and almost complete decerebrate rigidity phenomena.*

History.—J. L., a boy, aged 11 years, born in the United States, a Jew of Russian parentage, whose parents were first cousins, and who had three other children living and well, had had the disease for three years. It was noted that his left foot gradually began to "turn in" involuntarily when he walked; this became progressively more marked, and one year later his right foot also began to "turn in and to drop." In July, 1921, in the course of two days, there developed frequent spasmodic contractions in the left lower extremity, which made sitting difficult. The spasms steadily increased in severity and frequency. In September, 1921, the patient developed severe spasms in his hands. In August, 1921, walking became impossible on account of the muscular spasms and fatigability. In December, 1921, sitting became impossible, and the patient became bedridden. For the last two months the patient has been lying on his left side with the head turned to the left. Frequent spasms in the left upper extremity and the muscles of the back have also developed. For the last two months the right lower extremity has been held almost constantly in the extended position.

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1. Hunt, J. Ramsay: The Progressive Torsion Spasm of Childhood, J. A. M. A. **67**:1430 (Nov. 11) 1916.

Physical Examination.—The patient was unable to walk or stand. The position of election was the reclining one, with the body inclined to the left and the head bent forward and to the left. The left knee joint was in flexion, the right in extension. Both feet were in hyperplantar flexion, the right more

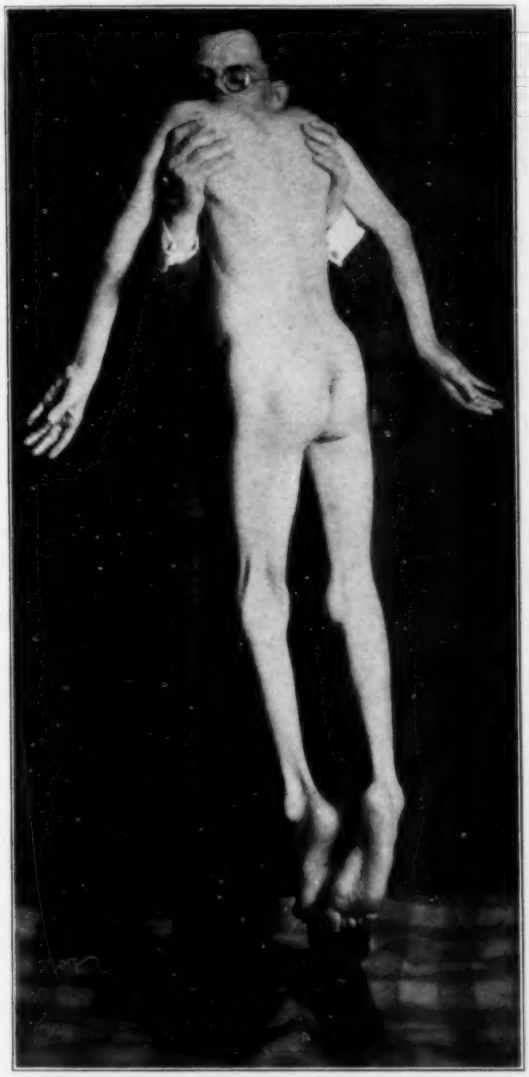

Fig. 2.—Almost total decerebrate posture in a case of dystonia musculorum.

so than the left. Occasionally the left upper extremity was extended with the palm turned outward. The movements came on in wavelike fashion and seemed to be induced by slight stimulation, such as stroking or pinching the skin. He frequently assumed an attitude of opisthotonos with the right lower

extremity markedly extended and the back in extreme lordosis. The abductors of the thigh, flexors of the leg and to a slight extent the adductors of the right thigh, were in almost constant tonic contraction.

If the boy was suspended by his upper extremities, he assumed a position typical of decerebrate rigidity: the forearms were extended on the arms, the fingers somewhat flexed at the proximal metacarpophalangeal joints, the forearm rotated outwardly (pronator sign), the lower extremities hyperextended and the back lordosed, forming an opisthotonic arc. However, the head was not retracted but hung limply forward with the chin pointing to the left (Fig. 2). There were no movements in the face or head musculature; the sternomastoids occasionally manifested mild tonic contraction. While there was no true pelvic distortion, there was a tendency to torsion toward the left. The erector spinae groups were in a state of constant contraction and occasionally the muscles of the back of the neck participated in the spasm. The muscles were in hypertonic contraction, but this could be overcome by passive movement, even to the point of hypotonia. Both the fingers and the hands

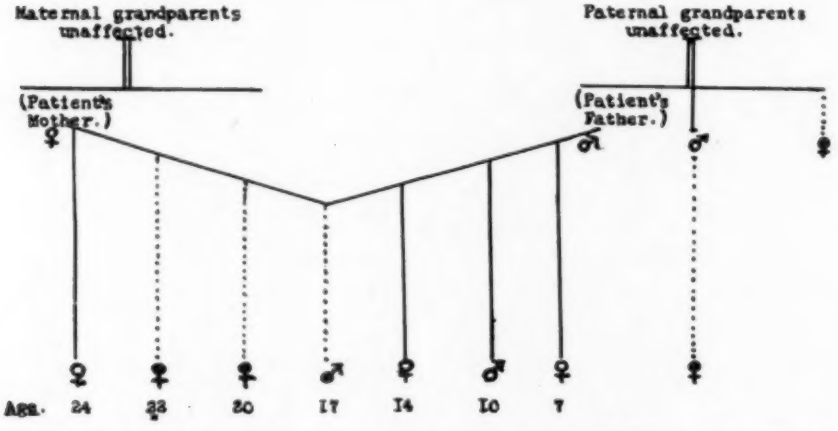

Fig. 3.—Familial incidence of dystonia musculorum deformans in Case 3. The black symbols indicate those affected with the disease. * indicates the patient.

were definitely hypotonic. There was no adiadokokinesis, no ataxia or dysmetria.

The deep reflexes were difficult to elicit. The abdominal and cremasteric reflexes were present. There were no sensory changes. The cranial nerves were normal, except for the existence of a true nystagmus on extreme gaze to the left.

Discussion.—The history of the development, the age of onset, the race of the patient and the abnormal involuntary movements stamp the case as a typical dystonia musculorum deformans, in spite of the fact that there is as yet no torsion of the pelvis. The unusual features are the postural decerebrate rigidity phases. Even as he lies on his back there are rhythmic waves of movement. (We have observed this rhythm in some of the other cases, and it is described in most of those reported in the literature.) The spasms throw the right lower extremity in extension and both uppers in extension, pronation and outward rotation. These movements represent momentary

phases of decerebrate rigidity phenomena. When the boy is suspended, all four extremities and the body assume the typical attitude which occurs on experimental section of the midbrain, with the exception of the position of the head. The occurrence of this phenomenon points to the anatomic delimitation of the lesion in dystonia, even if it does not strictly localize it.

CASE 3.—*An unusual case of dystonia musculorum deformans with (1) a remarkable familial incidence, (2) speech disturbance, (3) a remission of the hyperkinetic phenomena with a resultant (4) myostatic residuum, (5) a hemidystonic distribution, and (6) a fragment of decerebrate rigidity.*

History.—L. P., a woman, 21 years of age, born in the United States, was a Jewess of Russian parentage. A remarkable familial tendency to the disease was noted (Fig. 3). The illness began at the age of 12. Her gait became "dragging" and difficult. Later her upper extremities became involved. There was no history of precedent acute infection. The physical examination recorded by Dr. I. Abrahamson on April 5, 1920, revealed a bedridden patient with a typical dystonia with severe involvement of the body, head and neck and all extremities. The speech was dysarthric, bulbar in nature. In January, 1921, improvement was noted. The patient was quieter and able to take a few steps without support. In August, 1921, it was noted that the left hand still showed the rhythmic clonic movements, but there was a tendency to extension and pronation (fragment of decerebrate rigidity). The patient was able to walk fairly well. General dystonic movements were still in evidence. In February, 1922, there was marked remission of all movements with considerable general improvement (Fig. 4). She showed some dystonic movements in the left upper extremity with the rhythmic flexor-extensor movement of the hand at the wrist. The left foot was in equinovarus contracture and also exhibited movements, resulting in a left hemidystonia. The trunk and right side disclosed no movements but assumed the postural condition momentarily observed in the dystonias during the brief interval between the waves of movement; that is to say, that which is the fleeting static element in the kinetic disturbance has become a permanent postural attitude in this patient's remission.

Discussion.—In this patient, the onset of whose dystonia dates back to childhood, the condition began in the lower extremities and became progressively worse, until she exhibited a violent form of the typical kinetic disturbance. Added to that she showed a rare involvement of speech (bulbar dysarthria). So far as we are aware, only two other cases referred to in the literature reveal this disturbance (those of St. Bernstein[2] and Wimmer[3]). After two years, during which she became bedridden, a gradual remission set in. It may be of interest to mention that in August, 1920, she had a streptococcus sore throat, and in April, 1921, an acute follicular tonsillitis. One may speculate on the possible bearing of these infections on the remission. The quite remarkable familial history is also worthy of emphasis, in view of the familial tendency of some of the other striatal syndromes, especially since recent criticism tends toward the grouping of numerous clinical entities of a supposedly common basal ganglion origin. Further, although only few dystonic elements are left, they are practically limited to one side—hemidystonia. But

2. St. Bernstein: Ein Fall von Torsions Krampf, Wien. klin. Wchnschr. **25**: 1567, 1912.

3. Wimmer, A.: Etudes sur le syndrome extra-pyramidaux. Spasme de torsion progressif infantile (syndrome de corps strie), Rev. neurol. **28**:952 (Sept.-Oct.) 1921.

the striking feature of this residual state is the static or postural attitude, an attitude to which we also wish to direct attention in some of the succeeding cases and which we designate the myostatic variant, or counterpart, of the myokinetic syndrome.

Fig. 4.—Formerly a kinetic type of dystonia, now a myostatic variant exhibiting a hemidecerebrate posture.

CASE 4.—*A case of dystonia musculorum deformans, illustrating the myostatic or postural form, with few hyperkinetic phenomena.*

History.—P. T., a man, aged 20 years, born in Russia, a Jew of Russian parentage, whose illness began in 1913, at the age of 11, one year prior to

the onset fell from a height of about 12 feet, alighted on his feet but sustained no injury. One year later there developed a "drop foot" on the right side, associated with a turning outward of the lower extremity on walking. Three years later his hand began to turn outward, and he found difficulty in using it. About three years thereafter the left lower extremity became affected. The condition has remained stationary to the present day.

Physical Examination.—The patient walked with a peculiar gait, in which there was considerable twisting of the pelvis; the vertebral column was thrown forward, producing a marked lordosis; the lower extremities were rotated outward (everted) and in progression the trunk was bent forward and the lower extremities were flung about awkwardly in movements of hyperextension and hyperflexion (Fig. 5). A tendency to hyperadduction produced a scissor-gait effect. The abnormal movements and position of the spine and pelvis largely disappeared when the patient crept "on all fours." Despite the dystonic gait and the tortipelvis, the patient was remarkably free from tonic spasms when at rest. Except for an occasional tremor of the right upper extremity and clonic plantar flexion movements of both feet, there was a paucity of abnormal involuntary movements. There was no play of hypertonia and hypotonia in the affected muscles. A slight degree of hypotonia was present at the wrists.

The patient complained a good deal of various symptoms, was introspective, egocentric and was likely to use high sounding phrases. His attitude at times strongly suggested the functional.

Discussion.—The lack of progression, the atypical bizarre gait and attitude, the want of dystonic movements at rest, together with the patient's psychic make-up, speak in favor of a hysterical condition. But further study of the case convinces one of its organic nature and its relationship to dystonia musculorum deformans. For this patient shows the very postural or myostatic phase which may be momentarily observed in all the typical forms of the kinetic syndrome. But, whereas the postural static component is masked by the hyperkinetic phenomena in the general run of cases, in the present instance it has become the dominant feature. Corroborative evidence of the relationship of this syndrome to dystonia musculorum deformans may be found in the history of its development, the age and race of the patient, the torsion-posture of the pelvis, the lordosis, the clonic movements in the feet and the general attitude. The fact that the static phase is partially present in an undoubted case of dystonia musculorum deformans gives weight to the view that where the entire clinical syndrome is dominated by the postural component we are merely confronted with the complementary side of the same picture.

CASE 5.—*A postural or static instance of dystonia musculorum deformans (dysbasia lordotica progressiva) with slight kinetic involvement.*

History.—H. R., a man, aged 32, a driver, born in Russia, a Jew of Russian parentage, four months after a fall began to feel "stiffness and pulling sensation" in the hamstring muscles of the left thigh, followed by a "drawing sensation" in the left arm and forearm, with a tendency to flexion at the elbow and fingers. At the same time the left side of his face became involved in a similar muscular spasm. In 1912, a laminectomy (seventh cervical nerve to fifth dorsal vertebra) was performed, apparently in the belief that some cord involvement was the cause of his motor disturbance. Prior to the laminectomy alcohol was injected into the left elbow region and left popliteal space, appar-

ently with the unfulfilled hope of controlling the abnormal involuntary movements. Both of these operative attempts have left behind physical signs which are independent of the actual condition, yet serve to mask it.

As this case presents almost in its entirety the myostatic variant of dysbasia lordotica progressiva and may arouse doubt as to its proper classification in the group of dystonias, it may be mentioned that Drs. I. Abrahamson and J. Ramsay Hunt independently diagnosed the case (1919) as one of dystonia.

Physical Examination.—The patient was examined in February, 1922. There was frequent play of the muscles of the face, particularly of the upper lip, resembling a slow grimace. There was a slight tilt of the head and overaction of the platysma myoides. The right sternocleidomastoid was somewhat more

Fig. 5.—The lordotic attitude in a myostatic form of dystonia.

prominent than the left. There were few or no bodily movements with the exception of some in the toes, which appeared to be a cross between a dystonia and athetosis. On attempting to walk the movements of the toes gained in amplitude. On the right there was dorsal extension of the big toe and fanning of the others when the patient lifted his foot from the floor; this movement was of a dystonic type. There was a slow turning of both feet, especially of the right, into an equinovarus position. The lower extremities were held mainly in an extended position: the feet especially in plantar flexion. The right big toe was frequently held in spontaneous dorsal hyperextension. On suspending the patient by the arms both lower extremities were hyperextended at all joints.

The gait simulated a spastic walk with bilateral dropped foot. It was slow, wide, swinging and shuffling with a broad base, and appeared somewhat inco-

ordinate (Fig. 6). Yet there were no equilibratory and no deep sensory disturbances. The left abdominal reflexes were diminished, the lower deep reflexes increased. There was no true Babinski sign, but there were a left Mendel-Bechterew and a Rossolimo sign. There was neither hypertonia nor hypotonia in the right upper and lower extremities. A slight hypotonia was

Fig. 6.—A typical instance of the myostatic variant of dystonia musculorum. Note the spontaneous Babinski sign and the grimacing facial expression somewhat like that seen in progressive lenticular degeneration (Wilson's disease).

noted in the left lower extremity. There was flexor contracture of the fingers of the left hand into the palm. The left interossei were atrophied. Marked hypertonia was found in the left upper extremity, which was held flexed at an angle of 90 degrees at the elbow. The speech sounded as though the words were uttered through articulated teeth and partly closed lips. The labials

were especially interfered with because of the overaction of the lower facial muscles and platysma. The face appeared spastic, as if a smile were frozen on it.

Discussion.—There are a few physical findings in this case which complicate the picture, but it appears that they have been brought about by surgical interference and therefore do not form part of the syndrome. The contracture of the left hand, the atrophied interossei and the fixed hypertonic attitude of the left upper extremity are due to the therapeutic attempts which were made to control the abnormal movements. But the general posture and the few abnormal involuntary movements leave no doubt that the patient represents the myostatic variant of the hyperkinetic syndrome. His gait especially resembles to a marked degree that of the patients in Cases 3 and 4, and indeed that of every case of dystonia if one could subtract the abnormal movements. Additional corroborative evidence that the case belongs to the myostatic form may be found in the fact that the lower extremities assumed the hyperextended decerebrate postural attitude when the patient was suspended in the air with support under the axillae.

The speech disturbance was not of a dystonic character, but resembled more that encountered in progressive lenticular degeneration (Wilson's disease). This may be of some significance in linking together the two syndromes. The spontaneous dorsal extension of the big toe, while not a true Babinski sign, is worth remarking, and will be further alluded to in the next case.

Case 6.—*A case of dystonia musculorum deformans of the kinetic type revealing (1) fragments of decerebrate rigidity, (2) a paralysis agitans-like tremor of right thumb and hand, (3) a dorsal extension (Babinski) of the left big toe.*

History.—E. H., a young woman, aged 19, born in the United States, a Jewess of Russian parentage, had had a tenotomy of the left Achilles tendon in 1918. The illness set in gradually at the age of 8, first in the right foot and then in the right hand and upper extremity; later in the right foot; and finally the left upper extremity became affected.

Physical Examination.—The gait appeared somewhat spastic. She walked on the toes of the right foot and on the outer margin of the left sole. Both feet were inverted, the left more than the right. The right lower extremity tended to cross in front of the left. While sitting there were observed involuntary inversion of the left foot and occasional extension of both legs on the thighs. Now and then a spontaneous dorsal extension of the left big toe occurred. On extending the arms forward and above the head, the right underwent alternating supination and pronation with a tendency to eversion of the palm.

There were involuntary flexion and extension movements at the right elbow. At times there were small oscillations of the right thumb and hand in a manner closely simulating the tremor of paralysis agitans. The movements in the left upper extremity were much less marked. At times there was overextension of the left wrist and involuntary flexion of the fingers, together with flexion and extension at the left elbow. There were no involuntary movements of the head and neck and no torsion of the back or pelvis.

The reflexes of the upper extremities could not be elicited owing to the presence of the constant involuntary movements. The knee and Achilles' tendon reflexes were present and equally active. The abdominal reflexes were present and equal. On plantar stimulation there was marked dorsal extension of the left big toe and fanning of the others. This seemed to be an actual reflex response,

although a spontaneous dystonic Babinski movement also occurred. The cranial nerves were normal except for a slight bilateral horizontal nsytagmus.

Discussion.—The following facts are worthy of note: First, the restriction of the kinetic disorder to the extremities, giving an appendicular distribution. This emphasizes once more the possibility of the segmental involvement in the disorder, a point alluded to in connection with Case 1. Second, the presence of fragments of decerebrate rigidity in the right upper extremity and in the feet discloses the static component. Third, the paralysis-agitans-like tremor of the right thumb and hand is of particular significance, as it indicates a probable involvement of the efferent pallidal mechanism of the corpus striatum. The presence of this tremor may furnish another clue to the localization of the lesion. Fourth, attention should be directed to the presence of the Babinski toe phenomenon, which is even more marked in this man than in the preceding case.

SUMMARY AND DISCUSSION

The six cases summarized in this paper show a number of features which hitherto have not been associated with dystonia musculorum deformans. It is quite difficult to explain the nystagmus in three of the cases, unless it is assumed that the ocular movements are part of the dystonia. Although this is somewhat far-fetched, it may be pointed out that irregular movements of the eyeballs have been observed in violent choreas. So, too, it is difficult to interpret the presence of the Babinski sign in Case 6 without other signs of involvement of the pyramidal tract. Further, the fanning of the lesser toes and the dorsal extension of the big toe is occasionally observed in the same patient during the spontaneous movements. Case 5 also exhibits this spontaneous dorsal extension and fanning. One is tempted to speculate on the significance of the Babinski phenomenon and to question whether it is really primarily a pyramidal tract phenomenon or an unexplained striatal release mechanism.

The speech disturbances in two of the cases are also unusual. Two other cases reported in the literature showed similar disturbances. Wimmer's recent report mentions difficulty in speaking, but the statement is made that this was not a dysarthria. The speech was explosive; there was poverty of words and sometimes echolalia. There is no reason why the speech muscles should not be involved in dystonia in view of their undoubted striatal and cerebellar innervation. In this connection one may again instance chorea in which dysarthria is not uncommon. If an attempt is made to correlate dystonia with lenticular degeneration, it is not surprising that there is speech disturbance, although this is of quite a different type in the latter disease. The speech disturbance in Case 5 was somewhat reminiscent of Wilson's syndrome.

In many of the cases which we have described, and in numerous others reported, there is something wavelike or rhythmical to the movements. Rhythm in general is such a universal phenomenon and

in animal movement so primitive that special emphasis should be given to its presence in dystonia. Very likely it represents a reversion to a lower segmental characteristic of movement. In this connection it may be once more pointed out that two of the cases showed an actual tendency to segmental distribution of the affection.

The racial element, which, though very common, is not universal. was found in all of our patients. So, too, there was an apparent yet noteworthy functional tinge to some of the cases. It is well known that many of the patients in the early stages of the disease are considered hysterical. Case 1 bore the burden of that diagnosis for one year and Case 4 is still reminiscent of it, and yet there is no doubt as to the organic nature of the condition. Wilson's illuminating remarks on decerebrate fragments in hysteria may serve as possible explanations in this connection.

We called attention to the occurrence of decerebrate rigidity phenomena in the cases herein recorded. Wilson [4] made passing mention of them in dystonia, but he did not follow up his observations. His allusion, however, suggests a static component in the hyperkinetic disorder. The importance of the demonstration of this combination, as well as the dissociation, lies in the fact that it furnishes clinical evidence for the accepted notion of the physiologic unity of posture and movement. Conversely, there is sufficient physiologic evidence to support the view that there does exist a closely interwoven static counterpart of the kinetic form of the disease. The conception of movement as recently elaborated by numerous observers [5] permits the inclusion in one entity and proves the basic relationship of two apparently dissimilar clinical pictures, namely, the myostatic and the myokinetic variants of dystonia.

This enlarged conception is not altogether novel, at least from the point of view of correlating several clinical entities which are probably based on one anatomic substratum. Strümpell originally postulated an amyostatic syndrome in which he included Westphall's pseudosclerosis, Wilson's lenticular degeneration and paralysis agitans. At the same time that a special attempt was made to define the clinical syndromes of dystonia lenticularis (Thomalla) and double athetosis, attention was called to their common underlying physiologic mechanism and anatomico-pathologic substratum. The conviction has gradually arisen that the numerous clinical entities are not quite so capable of sharp delimitation as was originally thought. Attention was even drawn to the fact that disease of the liver may occur not alone with

4. Wilson, S. A. K.: On Decerebrate Rigidity in Man and the Occurrence of Tonic Fits, Brain **43**:220, 1920.

5. Goodhart and Tilney: Brady Kinetic Analysis of Somatic Motor Disturbances, Neurol Bull. **3**:295 (Sept.-Oct.) 1921.

lenticular degeneration but with dystonia musculorum deformans as well, thus showing that they are related in another way. Further, it was shown that far from being limited to the corpus striatum, the lesion in dystonia may be very diffuse. A recent review of the clinical syndromes of the corpus striatum by Lhermitte [6] lent but little clarity to the situation and only served to show that the same kinetic disturbance may be due to different lesions and that the same lesions may give rise to different kinetic disturbances. In other words, in the present state of our knowledge, it is futile to attempt too sharp a definition of the clinical or pathologic syndromes.

As few cases of dystonia have come to necropsy, Wimmer's fairly typical case may be cited in connection with the rather universal tendency to consider the disease one of basal ganglion, more especially lenticular, origin. On microscopic study Wimmer found cellular degeneration and neurogliar changes in the caudate and lenticular (putamen) nuclei, in the dentate nucleus of the cerebellum, in the thalamus, pons and cerebral cortex. The changes simulated those seen in pseudosclerosis ,and those found in the striatum were not more marked than elsewhere. Wimmer further quotes Spielmeyer to the effect that one might regard Wilson's lenticular degeneration, pseudosclerosis and torsion spasm as "variations in clinical expression of a pathologic process which is essentially the same."

Hall [7] has also pointed out that the pathologic process is not limited to the lenticular nucleus, but involves the pons and cerebral cortex as well. He further states that degeneration of the liver may be found alike in progressive lenticular degeneration, pseudosclerosis and dystonia musculorum deformans. Schneider [8] adds that hepatic cirrhosis may be found in dystonia lenticularis as well as in the syndromes just mentioned. In Wimmer's case, too, the liver was cirrhotic.

It may be of interest to point out that the syndrome under discussion is termed either dysbasia lordotica progressiva or dystonia musculorum deformans. There is no question that they are one and the same clinical entity. And yet one name stresses the peculiar postural attitude in the gait and the other emphasizes the abnormal movements. The important fact is that these two phases have been noted, although they have not been correlated.

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6. Lhermitte, J.: The Anatomical and Clinical Syndromes of the Corpus Striatum, Neurol. Bull. **3**:163 (May) 1921. Translated from the Annales de Medicine of August, 1920, by Huddleston and Kraus.

7. Hall, H. C. (of Copenhagen): La Dégénerescence Hepato-lenticulaire, Paris, 1921.

8. Schneider, Erich: Torsionspasmus: ein Symptomkomplex der mit Leberzirrhose verbundenen progressiver Lenticulardegeneration, abstr., Neurol. Zentralblatt **39**: (April) 1920.

The occurrence of a parkinsonian tremor in a true case of dystonia (Case 6) may serve as a further link in the chain of striatal syndromes. Paralysis agitans may be used by way of analogy to show that it is quite possible for either a kinetic or static phase to dominate a clinical picture. Just as there are cases of paralysis agitans which are characterized by tremor and others by the loss of associated movements and postural attitudes, so there are cases of dystonia which are made prominent by the abnormal movements and others which are signalized by the postural attitude.

CONCLUSIONS

1. There exists a myostatic variety of dystonia musculorum deformans as contrasted with the usual myokinetic form.

2. Phenomena of decerebrate rigidity may frequently be observed in dystonia musculorum deformans.

3. All cases of dystonia have an underlying postural background, one of the manifestations of which are the phenomena of decerebrate rigidity.

4. The myostatic and myokinetic phases of dystonia, which may be observed in all cases, are capable of dissociation. Either the static or kinetic phase may dominate the clinical picture.

5. The involvement in dystonia may be segmental in character.

6. In dystonia there occur not infrequently signs of other striatal diseases which point to a common anatomic and physiologic relationship.

DISCUSSION

DR. J. RAMSAY HUNT, New York: I should prefer to use the terms "rigid or paralytic type" for the group of cases described by Dr. Wechsler. If I am correct in my conception of the efferent system and its division into a kinetic and a static system, we shall in the future recognize groups of symptoms referable to the static mechanism. The corpus striatum is essentially a kinetic mechanism. When there is a striatal paralysis there follows naturally postural fixations, just as after hemiplegia from lesions of the corticospinal system. Therefore, why should the term "myostatic" be applied to express a paralytic manifestation of a kinetic mechanism?

In other disorders of the corpus striatum, for example paralysis agitans, we recognize a tremor type and a rigid type, and this makes a satisfactory clinical distinction. In my experience with dystonia these rigid or paralytic types represent late stages of the disease not unlike the late paralytic stage of paralysis agitans and athetosis when paralysis and rigidity replace the earlier motor disturbances.

I am, however, in entire sympathy with Dr. Wechsler's division of these two clinical groups, but it seems that it would be better to speak of them as a rigid or paralytic type rather than myostatic.

Abstracts from Current Literature

ON DECEREBRATE RIGIDITY IN MAN AND THE OCCURRENCE OF TONIC FITS. S. A. KINNIER WILSON, Brain **43**:3 (Nov.) 1920.

Sherrington has stated that "if in a monkey or cat transection below or in the lower half of the bulb has been performed, the animal . . . hangs from the suspension points with deeply drooped neck and tail, and its pendent limbs flaccid and slightly flexed. On giving the hand or foot a push forward and then releasing it the limb swings back into and somewhat beyond the position of its equilibrium under gravity; and it oscillates a few times backward and forward before finally settling down to its original position.

"To this condition of flaccid paralysis supervening upon transection in the lower half of the bulb the condition ensuing on removal of the cerebral hemispheres (mesencephalic transection) offers a great contrast. In the latter case, the animal, on being suspended in the same manner as after the former operation, hangs with its fore-limbs thrust backward, with retraction at shoulder joint, straightened elbow, and some flexion at wrist. The hand of the monkey is turned with its palmar face somewhat inward. The hind limbs are similarly kept straightened and thrust backward; the hip is extended, the knee very stiffly extended, and the ankle somewhat extended. The tail, in spite of its own weight . . . is kept either straightened and horizontal or often stiffly curled upward. There is a little opisthotonos of the lumbosacral vertebral region. The head is kept lifted up against gravity and the chin is tilted upward under the traction and backward rotation of the skull. . . . When the limbs or tail are pushed from the pose they have assumed, considerable resistance to the movement is felt, and, unlike the condition after bulbar section, on being released they spring back at once to their former position and remain there for a time even more stiffly than before."

Wilson points out the analogy between the foregoing experimental mesencephalic transection and the clinical phenomena observed in man when cortical function is lost. The cases are acute and are commonly the result of cerebral hemorrhage, meningeal inflammation, certain intracranial tumors and also hysteria. There occurs loss of consciousness, more or less complete, together with tonic rigidity of the trunk and limbs minutely resembling experimental decerebrate rigidity. Partial forms of decerebrate rigidity are hypothecated as arising in various organic and functional diseases, for example, in athetosis and chorea.

The author divides the various forms according to the following classification:

(1) Occurring with an associated loss of consciousness
- (*a*) Cases of decerebrate rigidity or attitude and tonic fits combined
- (*b*) Cases of decerebrate attitude without tonic fits
- (*c*) Cases of tonic fits without persisting decerebrate attitude

(2) (*a*) Cases of decerebrate attitude in conscious life
- (*b*) Incomplete, limited or fragmentary cases
- (c) Cases of decerebrate attitude in the course of conscious involuntary movement, especially chorea and athetosis

Under 1 (*a*) a case is cited of a young man, aged 19, who suffered four weeks with frontal headache. He fell unconscious, remaining so about twenty minutes, and afterward had intense headache. During twelve hours he had

ten convulsions of epileptiform nature. Later there were vomiting, giddiness and staggering. The left limbs became immobile, and he was drowsy. The left arm was adducted and flexed at the elbow, the left leg slightly flexed at the knee and the hip adducted. Both the arm and leg showed distinct rigidity. The clinical picture then changed. Unconsciousness developed, the arms became extended, rigid, and slightly flexed at the wrist; the legs were also rigid, extended and adducted with the toes pointing downward and inward. Later in the same day the arms rotated internally with palms facing outward and upward, and there was dorsiflexion of the great toes. Tonic fits occurred at intervals, but with no alterations of the decerebrate attitude in the interim. Death ensued seventy-two hours after the beginning of decerebrate attitude and necropsy revealed a vascular glioma on the under surface of the right frontal lobe, with hemorrhage filling the ventricles and extending under the meninges at the base and into the spinal theca.

A second case began with a "stroke" and left-sided paralysis, followed in a few hours by tonic fits and the decerebrate posture. Necropsy revealed an extensive hemorrhage in the right cerebral hemisphere with extension into the ventricles and beneath the meninges. A third patient gave a history of symptoms beginning six months prior to admission. "She lay in bed with face turned to the left, chin slightly up, the occiput to the right and rather down toward the right shoulder. The right arm was closely adducted to the chest, elbow at a right angle, forearm incompletely pronated, wrist extended, fingers and thumb slightly flexed. Extreme hypertonus was present, and voluntary movements were weak. The right leg was fully extended at the hip, knee and ankle, strongly hypertonic and immobile." Four days later tonic spasms set in on the left side, followed by stupor and immobility. Respiration was very much disturbed. Soon, however, she passed into a state of extreme rigidity in the decerebrate attitude. The tonic fits continued. The uvula on the following day contracted and relaxed alternately at a rate of about 120 per minute—a so-called "palatal nystagmus." At necropsy a tumor of the mesencephalon was found, invading the pons.

The fourth patient was a child with suppurative meningitis and an extension of the infection into the temporal lobe with abscess formation, which ruptured into the ventricles. Twenty-four hours before death she was in a decerebrate attitude, and until death exhibited tonic fits more severe on the left—but during which the decerebrate posture was more pronounced.

The fifth case was that of a child over 2 years of age, who assumed a marked flexor position with flexor hypertonus. Her attack began with an epileptic seizure after which she was apathetic, irritable and inattentive to excretory functions. Three days later the legs extended fully, but did not remain constantly so, and in two more days the arms extended also. The characteristic decerebrate posture was now present, and tonic fits supervened which accentuated the attitude. At postmortem examination a typical tuberculous meningitis was found with moderate internal hydrocephalus.

In each of the five cases, the decerebrate posture was found duplicating closely the experimental type. Extension-pronation of the arms and extension of the legs with the toes pointing downward was present in all. The tonic fits always accentuated the posture, and the author calls them "attacks of decerebration." Clonic spasms were never present, but respiratory disturbances were.

A child aged 15 months entered the hospital after a six weeks' illness characterized by vomiting after meals and an occasional stiffness and trembling

of the limbs. On admission the child was unconscious and the decerebrate attitude was present. The posture became intensified during the remaining nine days of the patient's life. Necropsy was not obtained.

(*c*) Cases of tonic fits without persisting decerebrate rigidity are less frequent than the foregoing types. The decerebrate rigidity attitudes are present only during the fits. Hughlings Jackson once described these tetanus-like seizures, calling them "cerebellar fits," and little has been added to his description. The author says that "it is possible to resolve these complete seizures into component elements . . . partial, incomplete, even segmental tonic attacks may be met with, and . . . some at least of the more or less fixed attitudes of the head and neck, trunk and of one or other limb, or part of a limb, encountered in certain basal, subtentorial and other lesions, are in reality functional fragments, so to say, of a non-cortical motor mechanism which finds its full expression in decerebrate rigidity and in complete tonic fits." Instances of both hysterical and organic types have been observed.

The case cited is that of a boy, aged 18, who complained of pains in the head, shakiness and drowsiness, after receiving two injuries to the head followed by unconsciousness. Two months later he had influenza and in two days his first fit. The fits recurred three or four times a week and were not amenable to treatment. During a fit the arms were extended and hyperpronated, hands clenched, wrists flexed, eyes rolled up and eyelids closed. The face appeared to be in a tonic spasm and the limbs stiff. Then he would slowly and seemingly deliberately turn the body around so that he lay on his face, the turning movement being accompanied by slow sterterous respiration. The body curved anteroposteriorly. In a few seconds he relaxed and the limbs could be moved like flails. After being turned on his back a second fit came on; the left arm went out in a tonic spasm in hyperpronation, the body arched backward in a powerful tonic contraction, the right arm extended and rotated internally, and then the body turned as before, following the left arm; this time he made a complete rotation, coming onto his back again. Relaxation and atonia followed. A third fit came on with contraction of the recti abdominis, bringing the body forward, but later there was opisthotonos and the arms went away from the sides followed by rotation of entire body, as before. The author comments on the purity of the tonic fits, the postures assumed being those of decerebration. He says that in persisting decerebrate rigidity the posture may be in part compounded of mutually antagonistic couples, which may be dissociated in the course of an actual tonic fit, one overbearing the other. "Where there is no persisting structural cortico-mesencephalic separation there is less likely to be fixity of posture."

Another case is cited in which a glioma was found, after death, in the middle lobe of the cerebellum and part of the left lateral lobe. There was also blood in the left lateral ventricle. Here tonic fits came on during a dressing of the wound after operation had been performed. Decerebrate posture was present with each fit. The author believes that the intraventricular hemorrhage and not the tumor was the causative factor of the fits and posture.

Comparisons between the arc de circle assumed in hysterical fits and decerebrate rigidity attitudes are mentioned. The author finds instances of decerebrate rigidity, though not diagnosed as such, in cases reported by numerous observers—notably Bastian, Hughlings Jackson, Dreschfeld, Drummond, Bacon, Stewart and Holmes, Douglas Firth, Eskridge, Turner and Bruce. Two cases by Bruce are mentioned, in one of whom an aneurysm of the anterior communicating artery had burst, filling the ventricles and sub-

arachnoid spaces, and in the other an aneurysm of the left anterior cerebral had ruptured, ploughing through the corpus callosum into the ventricles. Turner's case is recalled in which there was a tumor, at the level of the corpora quadrigemina, which had produced the typical rigidity of decerebration. This patient had a pyrexia of 111 F. (by rectum) and lived four weeks. The same posture occurs in certain instances of organic nervous disease, namely, Little's disease and forebrain aplasia.

2 (*a*). In hysteria the decerebrate posture is assumed but not held indefinitely, as in those cases in which cortical control and consciousness are cut off. The tonic spasms of tetanus are likewise somewhat similar, though parts of the attitude taken are seen in "cerebellar fits."

Cases of more or less complete decerebrate attitude are reported, the following case record illustrating the point. A child normally born did not walk or talk at the usual age; he did not use the arms freely and was stiff at the knees. There was some spasticity of the legs and rigidity of the trunk. When lifted up vertically the arms were adducted at the shoulders, fully extended at the elbows, powerfully inverted and hyperpronated with wrists extended and hands closed in flexion—a case of cerebral diplegia. A second case given showed a mixture of other symptoms with partial decerebrate attitude.

(*b*) The group of incomplete, limited or fragmentary cases includes types of decerebrate rigidity occurring in one limb or a segment of a limb, and depends on a complete corticospinal interruption of that fraction of the system. Hemiplegia is mentioned as showing a unilateral decerebrate attitude "only in a sense," namely, the adduction at shoulder, pronation of forearm and flexion of wrist and perhaps fingers. Sherrington is quoted as follows: "If instead of both cerebral hemispheres, one only, say the right, be ablated, the decerebrate rigidity appears though not with the same certainty as after double ablation, chiefly on the same side as the hemisphere removed. The monkey, when slung after ablation of one, for example, the right hemisphere, exhibits generally the following attitude. The right limbs are extended in the pose described as characteristic for decerebrate rigidity; the tail is strongly incurvated toward the right, that is, its concavity and tip are toward the right. It resists passive movement to the left, and if displaced thither, immediately on being released flies back. The head also is pulled toward the right and retracted. The left forelimb . . . is sometimes distinctly more flexed than would be expected in the paralyzed condition of the animal; the left knee likewise. . . . The contrast between the attitude of the crossed and homonymous sides is very striking. . . . Homonymous extensor rigidity . . . is neither so constant . . . nor so persistent . . . as the rigidity following bilateral ablation. . . . It may totally subside and again reappear . . . as though a tonic influence from the still intact crossed hemisphere at times overcame and at times was overcome by another opposed influence from a lower center."

A case in point is that of a child aged 2 who, at the second or third month "lay like a doll" in bed. Use of the right arm began at six months in a jerky way and kicking movements of the legs followed. He had never held up his head nor talked. From the 18th month to two years, restless and jerky movements were more obvious. On admission emotion was shown only by crying. The power of the limbs was feeble and volitional control erratic. When lying on his back he kept the right arm level with the shoulder and flexed to a right angle at the elbow, the forearm midway between pronation and supination, the wrist somewhat overextended and the fingers and thumb flexed; the left arm was usually fully extended and close by the side or slightly adducted, the fore-

arm pronated and the hand closed in a fist. The right leg was flexed at the hip and knee, everted and abducted, with heel drawn upward and toes pointing downward; the left leg was like the homolateral upper limb—extended in full and sometimes slightly abducted. The head was usually turned to the right and somewhat retracted. Moderate muscular tonus was present. Choreiform movements interrupted the posture described and were particularly noticeable when the child was suspended by the axillae. Hughlings Jackson, in 1872, mentioned that "in some cases of cerebellar disease there is only a fragment of the tetanus-like condition" which is significant in the light of recent interpretations of lesions in the brain stem or hind brain. In unilateral cerebellar disease the head is tilted back and the occiput turned to the side of the lesion. In bilateral cases the one tendency neutralizes the other but the retracting element brings the head back, which is the condition found in decerebration. The opisthotonos of decerebrate rigidity is explained on the same basis, the one rotating element neutralizing the other and the curving of the trunk and spine combining in both. Such conditions are probably not brought about by cerebellar conditions as most of the cases in the author's experience have shown mesencephalic lesions at necropsy.

The "pronator sign" is pointed out as characteristic in cases of decerebrate rigidity affecting one limb or a segment of a limb. The case of a child aged 12 is given. This patient had all the general symptoms of an intracranial tumor, which was clinically localized in the left cerebellum by a somewhat indefinite reeling gait. Operation was performed, and removal of a part of the left lateral lobe disclosed a small tumor at the left edge of the middle lobe. During the operation skew deviation developed, and ten days later when the left arm was extended it assumed an attitude of marked pronation and inversion. The left leg likewise was held extended and inverted at the foot, and the head assumed the posture of occiput to the left.

(*c*) In cases of partial decerebrate attitude occurring as involuntary movements in the course of chorea and athetosis, the "pronator sign" is observed during the movements in chorea. In athetosis, pronation is a most frequent posture. Both argue for a mesencephalic disturbance. A child of 3½ years was microcephalic and diplegic. When placed on his back and the head turned to the left the limbs were in moderate flexion, but on turning the head to the right an immediate extension of the left arm into the decerebrate attitude was always obtained.

In dystonia musculorum deformans, or torsion spasm, one or other of the limbs may assume the decerebrate posture.

Pathogenesis of Decerebrate Rigidity: Clinical evidence of transection at the mesencephalic level is not lacking, but the anatomic details must be supplied, for the present, from the experimental side. Attention is called to the disturbance in respiration which has occurred both in experimental and actual cases of removal of cortical control. The author suggests that there is herein evidence of a respiratory tract and a center which is situated near the nucleus ruber, and not in the cerebellum.

Hughlings Jackson's early statements concerning the "co-operation of antagonism" between cerebrum and cerebellum is set forth in his studies on hemiplegic rigidity. He says that there is present normally a positive and negative condition. "Negative states of the nervous centres cannot *cause* positive states of muscles, they may *permit* them." He speculates believing that the "rigidity is owing to unantagonized influence of the cerebellum. The cerebellum is the centre for continuous movements and the cerebrum for

changing movements. The former are tonic, the latter clonic." In walking, the cerebellum maintains the posture while the cerebrum initiates the changing movements. The unimpeded cerebellar control which occurs when the cerebrum is cut off gives rise then to rigidity. This condition accounts for the "negative and positive conditions in the contractures of hemiplegic children, in the athetosis of Hammond . . . rigidity and propulsive walk in paralysis agitans; temporary removal also for tetany and certain hysterical attacks and also for some post-epileptic conditions of movements." It cannot be said, however, that the chief rigidity-producing influence lies in the cerebellum, and it does not mitigate against the facts proved by decerebrate rigidity, that the lower centers are released when the higher are abandoned.

For the development of decerebrate rigidity the lesion is of necessity limited to the mesencephalon, cerebellum and pons, although certain influences arising in the basal ganglions cannot be denied. Granted that the spinal proprioceptive centers are intact, rigidity arising from mesencephalic transection can be abolished by section of afferent roots. Sherrington has said that ascending impulses to maintain tone are not transmitted through the dorsal columns, as section of these has no effect, whereas section of the ventrolateral cord abolishes rigidity. Weed believes Gowers' tract is the path and not the dorsal, since section of the inferior cerebellar peduncles does not influence the rigidity. Excitation of the anterior (superior) surface of the cerebellum from near the midline outward to near the lateral border of the cerebellar surface abolishes rigidity, as observed by Sherrington, Lowenthal and Horsley, Weed and others. From this it is argued that destruction of the same area might produce rigidity, and this has been observed by Sherrington and Thiele, though not constantly. Rigidity has persisted after removal of the cerebellum, and has been produced by stimulation of the midbrain after total removal of the cerebellum. It is concluded therefore that the "functional integrity of the cerebellum is not a condition sine qua non" for the appearance of rigidity after mesencephalic transection.

The real origin of decerebrate rigidity is placed by Weed in the region of the colliculi, particularly in the red nucleus. The red nucleus is of prime importance for the "reflex of standing," and the afferent impulses from the spinal centers stimulate it to tonizing functions. When the cerebral control is removed the tonizing effect goes on unchecked, the cerebral inhibiting fibers being found, according to Weed, in the frontopontocerebellar pathway. Stimulation of this pathway experimentally always inhibited decerebrate postures. The connection of this pathway traced by Weed to the anterior portion of the superior vermis suggests the explanation for the inhibition of rigidity when the anterior (superior) surface of the cerebellum is stimulated.

The mechanism of decerebrate rigidity is shown in the work on monkeys by Graham Brown. Points of stimulation, that is, "focal points," in the midbrain, which produce the phenomenon, are located by him on "either side of the midline at the level of the colliculi some millimeters ventral to the aqueduct, thus corresponding to the red nuclei (and possibly also, with that of the posterior longitudinal bundle)." Stimulation of one area produces a flexion of the arm of the same side and extension of the opposite, these postures remaining after cessation of stimulation. The tail bends to the same side, the homolateral leg extends and the contralateral leg flexes; the head is turned away from the stimulated side. "A successive compounding of the two focal points has produced bilateral extension, and bilateral flexion."

The elements of decerebrate rigidity are mutually reinforcing and mutually antagonistic. The extension of all limbs is due to influences from the red

nucleus, or is affected by them. The unisegmental attitude, such as the pronator sign, is supposed to arise from partial red nucleus activity. The large type of cells in the red nucleus may represent combinations of anterior horn cell groups of the cord, a re-presentation. The antagonism between the red nuclei lies below the midbrain, as low as the spinal centers. Therefore the section of the mesencephalon allows uncontrolled innervation of the anterior horn cells by the centers which influence them in the red nuclei, thereby producing the attitude of rigidity. The tonus produced, is, according to Sherrington, "reflex standing."

It is probable, however, that the red nucleus is not alone responsible for postural activities, and the author mentions "Edinger's nucleus motorius tegmenti, which consists of associated motor-cell groups scattered through the pons and mesencephalon to the level of the neutral optic thalamus, including Deiters' nucleus," and it is not likely that the effect of stimulation is limited "to one descending rubral path, the rubrospinal." Thiele has stated that Deiters' nucleus and not the red nucleus conducts the impulses of decerebrate attitude to the lower centers. Magnus and de Kleijn support a labyrinthine agency.

The author closes by mentioning the connection of the red nucleus and involuntary movement, quoting Jackson as follows: "tremor differs from rigidity not fundamentally but in degree."

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THE ANATOMIC CONDITIONS OF BINOCULAR VISION. M. MINKOWSKI, L'Encephale **17**:65 (Feb.) 1922.

The author's contribution is based on a study of secondary degeneration in the optic nerve, chiasm, the optic tracts, the primary visual centers and the cortex, following enucleation or loss of one or both eyes. His own work was done on tissues of the rabbit, cat, goat, monkey and man. The chief contribution to the anatomy of binocular vision is a study of the structure of the external geniculate bodies and their afferent and efferent tracts.

By the time they leave the chiasm the fibers of the optic nerves have a definite arrangement which persists in general throughout the optic tract. In man three zones are distinguishable: a ventromedial composed chiefly of crossed fibers, a central composed of direct and crossed fibers and a dorsolateral composed chiefly of direct fibers. The author believes that the central zone probably contains fibers composing the macular bundle.

The optic fibers enter the anterior corpora quadrigemina. In the lower mammals they enter by the peduncle and terminate in the periphery, thus forming a superficial mesencephalic root of the optic nerve. In the macacus monkey there is an interesting bundle composed of crossed optic fibers which reaches the inner portions of the anterior corpora quadrigemina. These fibers separate from the medullary capsule of the external geniculate body, passing first into the arcuate fibers which surround them, and then continuing in a distinct bundle located internally and posteriorly to the medial side of the internal geniculate body, reach the anterior part of the anterior corpora quadrigemina. They finally pass with the ribbon of Reil and probably terminate in the gray and white layers of the anterior corpora quadrigemina. On this account the author feels justified in designating this fiber system the deep mesencephalic root of the optic nerve or dorsal ribbon of Reil.

As for the pulvinar of the thalamus, the author holds that the total number of fibers terminating in it is small and probably composed equally of crossed and direct fibers.

After loss or enucleation of one eye there appear in quite different parts of the two external geniculate bodies, a reduction of the intercellular molecular substance and diminution in quantity of the ganglion cells and neuroglia reactions. From this the author concludes that the direct and crossed optic nerve fibers have each their own terminations, whose limits correspond to the areas of degeneration shown in the external geniculate bodies. The latter are divided into a certain number of cell layers by medullary lamellae; this stratification is evidence of the existence of separate fields for crossed and direct optic nerve fibers. In an animal with one eye destroyed, the atrophy occurs in particular cell layers of the external geniculate bodies and alternates in the external geniculate bodies of opposite sides in such a manner that the layers atrophied on one side are normal on the other. In general, the crossed optic fibers end in the external part of the external geniculate bodies. In the posterior portion of the external geniculate body the cells diminish in number, whereas the geniculocortical fibers, which originate as the axis cylinders of the cells of the external geniculate body, increase. Thus, the external geniculate bodies serve as the chief relay station of the subcortical optic pathways. The author says that the external geniculate body plays the most important part of all the primary visual centers of higher animals and man in transmitting retinal stimuli to the cortex. It is through it that the cortex is activated and also by means of the corticofugal paths extending to the corpora quadrigemina and transmitting stimuli to the oculomotor nuclei that the simple visual reflexes such as those of convergence and accommodation are controlled.

The author could not settle the question of the existence of a reciprocal relation between the two chief fields of distribution in the external geniculate bodies, especially between the portions receiving stimuli from corresponding or slightly different portions of the two retinas. He points out that the atrophy of particular layers in the external geniculate bodies after enucleation of one eye is more marked than after destruction of both eyes. This suggests that in a one-eyed animal or man, stimuli going from the normal eye to the external geniculate bodies have an inhibitory rather than an excitatory influence on the elements derived from the destroyed eye, and thus favor the atrophy of these elements. If this is so in the blind, the author suggests that in normal binocular vision there also exist reciprocal relations both of excitation and inhibition between the elements of central representation for the corresponding parts of the two retinas. Central representation of the various sectors of the retina in the external geniculate bodies has not been dealt with by the author.

In man and monkey there is an accessory nucleus of the external geniculate body, the gresium praegeniculatum, which has been described as a part of the reticular zone and thalamus. From a study of secondary degeneration, the author classes this nucleus among the primary visual centers. The gresium praegeniculatum commences a little anterior to the anterior portion of the external geniculate body in the dorsolateral angle of the optic tract. Its internal portion passes to the subthalamic region and lies alongside the ventral nucleus of the optic thalamus. Its cells are extremely small. After enucleation of one eye the contralateral gresium praegeniculatum shows partial atrophy, thus indicating that the crossed optic fibers and possibly some of the direct fibers end in it. The function of the gresium praegeniculatum is not definitely known. Lesions about the calcarine fissure or of the optic radiations produce secondary degeneration in it.

Fig. 1.—This illustration shows how the degeneration affects particular layers of the external geniculate body. The section is frontal, through the middle left external geniculate body, eight months after enucleation of the left eye. *1*, medullary capsule of the external geniculate body; *2*, external geniculate body; *3*, normal peripheral stratum of the medium size cells; *4*, atrophied intermediocentral stratum; *5*, normal intermedioperipheral stratum; *6*, atrophied central stratum of the medium size cells; *7*, atrophied central stratum of the large cells; *8*, atrophied peripheral stratum of the large cells; *9*, normal basal medullary lamina with its small cells; *10*, degenerated medullary lamina between the central strata of the large and medium size cells.

Since loss of an eye produces distinct atrophy in certain definite portions of the external geniculate bodies, we can assume that the axis cylinders of these cells which comprise, as geniculocortical fibers, a large portion of the sagittal radiations of the parietal and occipital lobes (Meyer's bundle—radiations of Gratiolet) also undergo an alteration, at least when the cellular atrophy is at

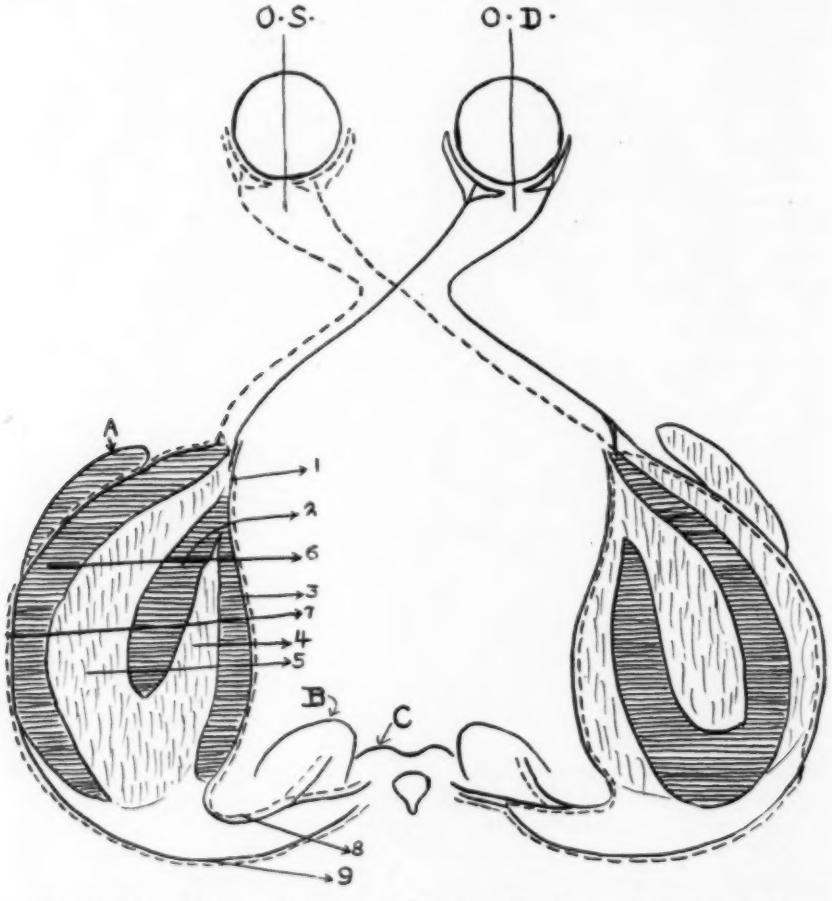

Fig. 2.—The right eye has been destroyed. The heavy lines denote degenerated areas in the external geniculate bodies. *A*, griseum praegeniculatum; *B*, pulvinar; *C*, corpus quadrigeminum anterior; *1*, medial basal lamella; *2*, intermedioperipheral stratum; *3*, large cell peripheral stratum; *4*, large cell central stratum; *5*, central stratum; *6*, peripheral stratum; *7*, medullary capsule; *8*, superficial optic fibers to pulvinar and anterior corpora quadrigemina; *9*, deep optic fibers to anterior corpora quadrigemina.

all advanced. This is the case in the monkey. This alteration is more or less uniform throughout these radiations, and suggests that the fibers coming from the homonymous portions of the two retinas are more or less intermingled. After partial lesions of the optic radiations and calcarine cortex, both in monkey and man, secondary degeneration of the external geniculate body usually occurs, without any alteration in the different layers of the external geniculate

bodies related to these radiations. On the other hand, this degeneration often spares almost indentical portions of two adjacent cellular layers. From this the author concludes that the fibers of the radiations are not only intimately intermingled, representing both crossed and direct optic fibers, but that they are also distributed in such a way that the fibers originating from adjacent cellular fields of the external geniculate body occupy adjacent positions in the radiations, and represent, as do the cells of origin, corresponding or slightly different parts of the two retinas.

The representation of the external geniculate bodies in the cortex corresponds to the area striata, and lesions of this region alone can produce degeneration in the external geniculate bodies. The author's researches show that the intracerebral subcortical neurons re-represent in the calcarine cortex the arrangement of fibers described for the external geniculate bodies.

Although one may admit in principle the existence of special fields of representation of the homonymous portions of the retinas in the cortex, the author does not believe that the conditions are precisely analogous to those existing in the external geniculate bodies. In the cortex there is no need for a distinct limitation of any two fields, and the possibilities of correlation and association between them are infinitely greater than in the external genicular bodies. In any event, these fields are connected with the retina by means of the external geniculate body. The frequency of stimulation of a given neuron determines to the same extent the selection of associated pathways being used. Two stimuli of monocular origin, which are alike but not identical, probably exert a reciprocal influence on the external geniculate bodies, but it is only in the cortex itself that these two stimuli fuse into a single binocular sensation. The associative connections favoring the fusion of stimuli of monocular origin are developed between portions of the visual cortex and are frequently called into play by similar and synchronous stimuli. Different portions of the two retinas, as well as of one retina, are capable of numerous functional correlations, and the author believes that for each different element of the single retina there are in the cortex anatomic and functional connections with different parts of the same and the contralateral retinas. Thus, in speaking of the field of representation of the two homonymous portions of the retina, one has in mind not a fixed and rigid geometrical scheme of representation but rather a complex and variable scheme in which the physiologic law of habit exerts its influence and which thus makes possible combinations which vary from one moment to another, under the influence of different physiologic factors—such as the flow of stimuli, as well as memories of previous stimuli.

The various fields of re-representation in the cortex constitute a step in the organization of visual stimuli coming from the two eyes. The question of the re-representation of the crossed and direct fibers in the cortex has been studied by different authors. The author believes that the theory of Wilbrand and Saenger, which is also adopted by Henschen, is well founded clinically. According to this theory, the central fibers serving for the representation of the homonymous portions of the retinas terminate in small adjacent fields of the cortex, which are placed like squares on a checker board, one field representing crossed and the other representing direct fibers, composing in this fashion a mixed field with a single physiologic function. Wilbrand and Saenger hold that there is a special field of representation for the internal portion of the retina present in the contralateral hemisphere only. In any event, it must be remembered that there is some reorganization of stimuli from the retina when they reach the external geniculate bodies, and whatever the cortical representa-

tion may be, it is dependent on the function of the external geniculate bodies as relay stations. The simple visual stimuli acting on the retinas are first organized in the external geniculate bodies. Then through cortical activity, more complex organization results.

HYSLOP, New York.

THE PATHOLOGY OF THE PSYCHOSES OF SENILITY. FRANCESCO BONFIGLIO, Rev. sper di fremiat. **45**: Pts. 3 and 4 (Jan. 31) 1922.

This sterling worker in the field of neuropathology and psychiatry reviews the whole question of the psychoses of old age, reaching the following conclusions:

1. There are two distinct groups in the psychoses of advanced age: the arteriosclerotic and the senile dementias.

2. Cerebral arteriosclerosis is characterized by alterations in the large and small vessels, both meningeal and endocerebral, which frequently produce focal symptoms due to hemorrhage or softening. Besides these purely vascular conditions, there are definite changes in the brain parenchyma which, however, are always secondary to the former and are to be found in circumscribed areas of the brain which are supplied with blood by the affected vessels. So that alongside of areas of the brain gravely altered by this process are to be found well preserved areas. Therefore, the characteristic findings in arteriosclerotic brains are the more or less numerous, smaller or larger areas of altered brain tissue. The histopathologic complexes are at least two in number. The most common, described by many authors and summarized by Alzheimer and Rossi, shows sclerosis of the cells, deposits of lipoid pigment, necrosis, destruction of nerve cells and degeneration and destruction of nerve fibers. Also, according to the stage and severity of the lesions in the nerve elements, one finds proliferation of the neuroglia with formation of glia scars or frequently ameboid degeneration of the glia cellular elements. Hand in hand with this, there is an abundant accumulation of products of decay with consequent infiltration of this material into the neuroglia and vascular elements.

The other less frequent picture is the so-called productive form, described first by the author in cases of grave intoxication, and later by Gerletti and Livi in cerebral arteriosclerosis. This process is found in the ischemic areas or in their limiting zones and is characterized by intense global degeneration or even necrosis of all the ectodermal elements and active proliferation of the cells of the walls of the blood vessels—so much so that the chain of vessels in the affected area appears to be composed of large impervious cellular cords.

3. Senile dementia has a definite anatomic picture of its own, easily differentiated from that of cerebral arteriosclerosis or for that matter from any other picture already described. The cortex is diffusely affected by a primary degeneration or destructive process, involving the nervous elements, with infiltration of lipoid pigment and regressive or in part proliferating reactions in the glial elements. Especially characteristic findings are the "senile plaques" of Redlich and Fischer and the change into large "fibrils of Alzheimer." The plaques are constantly found, but the "fibrils of Alzheimer" are not. They, however, are more frequently present in the older and more advanced cases. The lesions in the blood vessels when there is no real arteriosclerosis complicating, are secondary to the processes of degeneration or caused by the atrophy of brain tissue. The later changes are the vascular nodes and grooves described by Gerletti.

4. Senile plaques and the large fibrils are never found in any other condition. Despite much work, the origin and nature of these specific pathologic changes are still obscure. Perusini, who first described them in the entity which Kraepelin designated "Alzheimer's disease" (presenile dementia) thinks that the "plaques" are due to the deposit in the neuroglia syncitium of special pathologic products. As to the large fibrils, the author thinks that, in part at least, the change is dependent on the neurofibrils. They have the same characteristics as the changes found by Donaggio in the neurofibrillar elements of animals exposed to cold and hunger. They are not identical with the changes found by Cajal in rabies, but somewhat similar. It is of interest to note that Gerletti has found these changes only in certain groups of cells in the hippocampus. The author thinks the plaques and fibrils have a common origin.

5. While the process in senile dementia is diffuse, it especially attacks the frontal lobes and the cornua ammonis in the vast majority of cases.

6. In a small number of cases which were grouped with the senile psychosis after the typical pathology was found, other portions of the cortex were found involved—the temporal lobes, the parietal and occipital (causing the aphasic, agnostic and apraxic symptoms of Alzheimer-Perusini's disease). In fact, the presence of aphasias and asymbolia and other focal signs in these cases differentiates them from true senile dementias, especially as they occur in persons who are chronologically not senile (30 to 50 years). They should be grouped and called "the senile dementia of Alzheimer-Perusini."

The cases of senile circumscribed cerebral atrophy described by Pick have not been well studied histopathologically. One can say, therefore, that they are or are not cases of cerebral arteriosclerosis or of Alzheimer-Perusini's disease.

7. The distinction made by Fischer between simple senile dementia and presbyophrenic dementia is not valid either from the clinical or the pathologic standpoint. Clinically, the cases described by Fischer as presbyophrenia are the senile dementias of other psychiatrists, while pathologically his simple senile dementias present the same characteristic pathologic findings mentioned in the foregoing.

8. The question of whether the basis of the pathology found in senile dementia is an accentuation of the same process occurring in ordinary old age or whether it is to be considered as an entity is a problem which must be left sub judice. The finding of the same histologic picture in the normal aged (80 to 100 years) by Oppenheim, Gerletti, Constantin and the author, seems to give some weight to the contention that we are dealing with a normal involution process which, becoming accentuated, finds its most favorable soil in senility. On the other hand, the fact that the senile plaques and fibrils are not found in the simple senile atrophic processes of other organs and further that they have been searched for in vain in the brains of old animals, would seem to show that neither of these processes is caused by the simple senile involutive processes of the brain.

9. The two diseases—cerebral arteriosclerosis and senile dementia—being clearly distinct entities, the remaining psychoses of old age may be subdivided into two further groups: (1) one with a pathologic picture not well individualized but different from either of the foregoing, and (2) a group whose histopathology is not known. To the first must be added all those cases described by Kraepelin, Alzheimer, Ziveri and Spielmeyer, most of which begin in the presenile age, have a varied symptomatology and course (paranoid

pictures or katatonic syndromes of the manic-depressive, agitation types, etc.) but which have in common the same unhappy ending with great mental degeneration. They present profound histopathologic changes which are not, however, specific. For this reason it is impossible to say that the same cause underlies all of these cases or that the morbid process is varied. Neither is it possible to say what connection they have with senile involution. It is certain that these cases, however, must be kept distinctly separate from the cerebral arteriosclerosis and the senile dementias.

In the second group we must place all those cases which are still called "functional" and which are grouped according to symptomatic criteria, which are frequently varied to suit the views of various authors; as, for instance, the Kraepelinian conception of involution melancholia, the presenile depressive deliria, the presenile delirium of persecution and late catatonia. It has not been proved that all of these forms are related to senile involution. The article is written in a scholarly, concise way and is worth reading in the original.

OSNATO, New York.

TRANSORBITAL PUNCTURE OF THE GASSERIAN GANGLION. CHESTER M. VAN ALLEN, Ann. Surg. **74**:525-545, 1921.

The author, in his discussion of transorbital puncture of the gasserian ganglion, gives an excellent review of the various technics employed in alcohol injection, and describes briefly the Harris and Hartel technics of ganglion injection. He reviews the bibliography, and presents the anatomy of the orbit and of the middle cranial fossa, illustrating clearly the particular points involved in the transorbital puncture of the gasserian ganglion. He describes his own technic, stating that a small incision is made just below the pulley of the internal oblique muscle, the periosteum leading into the orbit is loosened, the needle is inserted underneath the periosteum against the pulley and is passed underneath the optic nerve through the sphenoidal fissure into the gasserian ganglion.

The results of a laboratory investigation on twenty-four cadavers available in the dissecting rooms of the department of anatomy, Yale School of Medicine, are reviewed. Bilateral gasserian punctures and injections with methylene blue were carried out. After each injection a strand of wire was inserted in the needle bore and allowed to remain as an indicator of the pathway followed. Careful dissections were then made in each case to study this pathway and to determine the behavior of the injected fluid. Of fifty-two consecutive punctures, forty-three were shown to enter and successfully to infiltrate the ganglion root. Of the remaining nine, two on a microcephalus and two on a child of 8 years may be eliminated, as the anatomy was not that of the normal adult skull. Five punctures were failures—four because the needle terminated within the cavernous sinus, and one because, for some unascertained reason, the sphenoidal fissure could not be found. From an anatomic standpoint, the technic shows an efficiency of 90 per cent. In view of the experimental evidence, the author felt justified in trying it on a few patients on whom general anesthesia was not indicated and on patients suffering from trifacial neuralgia when it was advisable to make injections into the gasserian ganglion. The results obtained in five cases are reported. In three cases local anesthesia was employed for blocking the fibers of the fifth nerve in order to permit operative procedures on malignant lesions in aged patients. A few drops

of alcohol were injected into two patients who were suffering from trifacial neuralgia. In four cases anesthesia of the entire trigeminal field was produced. In one case the needle failed to reach the ganglion, and this can be ascribed to only one cause—some slight variation in the bony contour of the skull. Whether successful or not, the passage of the needle in these instances caused no serious damage to the patient. The orbital portion of the route was entirely painless; the passage behind the orbit intensely painful. In two of the cases the fact that the cavernous sinus was transfixed was demonstrated by suction of the needle during its entrance; in two cases no effort was made to determine whether or not the sinus was injured; and in one it was self-evident that the needle had entered the sinus. Yet in no instance were there symptoms to indicate intracranial or retrobulbar hemorrhage. The subcutaneous ecchymosis that followed puncture in three cases was of no greater extent than could be attributed to any such traumatism to these tissues; and the orbital edema in one case was probably induced by a few drops of alcohol left in the orbit by the retiring needle, a complication preventable by negative pressure exerted on the needle during its withdrawal. In three cases, when the bony terminus was reached and the stylet removed, cerebrospinal fluid flowed from the needle; venous blood exuded in one case, and in one case the puncture was dry.

The presence of cerebrospinal fluid at the end of the passage indicates that the cave of Meckel is reached and that injection of solution will involve the ganglion root; the presence of blood indicates clearly that the needle has stopped within the cavernous sinus and that further attempt to reach the ganglion should be abandoned. A dry puncture means that the needle has entered the lower part of the ganglion below Meckel's cave and an injection of solution will flow upward into the cave and thereby infiltrate the nerve root, or that the needle missed its mark and has come to lodge in some nonvascular tissue. The author says that in his experience with the injection of stain in cadavers, if more than a few drops of fluid are placed in Meckel's cave, it will discharge posteriorly into the basilar cistern. The cave is apparently in free communication with the subarachnoid spaces at the base of the brain.

The author feels that the results of his work, both anatomically and clinically, lead him to believe that transorbital puncture of the gasserian ganglion furnishes a relatively simple means of securing block anesthesia for operations in the territory supplied by the trigeminus, and is fully justified in cases in which general anesthesia is contraindicated.

ADSON, Rochester, Minn.

A PSYCHOLOGIC INQUIRY INTO THE NATURE OF THE CONDITION KNOWN AS CONGENITAL WORD BLINDNESS. LUCY G. FILDES, Brain **44**:286, 1921.

The author feels that there may be some analogy between the cases of congenital word blindness and the alexias acquired as a result of morbid processes in the brain. The theories previously set forth to explain the condition are: (1) the assumption of definitely localized circumscribed visual and auditory word centers in the brain, destruction of which destroys language in its auditory or visual aspects, or (2) word blindness, which is only one symptom of a general lowering of mentality, and (3) a condition that is due to a special lowering in the primary visual centers, making visual perception of words and other "sense data" difficult.

The psychologic problems are two: Is inability to learn due to a general or specific defect? If the former, does it show itself only in reading, or is there a general lowering of visual power?

The subjects used for the investigation were twenty-six children, between the ages of 9 and 16 years, four attending ordinary elementary schools and twenty-two, schools for the mentally defective. They all had difficulty in reading. According to the Terman scale, the intelligence quotients varied from 50 to 111, as follows: The intelligence quotient in one was 111, in four from 82-88, in eight from 70-79 and in thirteen from 50 to 69 (morons). The interesting fact is mentioned that the fifth boy of the first two groups was in a school for mental defectives and fell below all the other four in general ability—but, in reading ability, he was better than the boy with the highest intelligence quotient who was poorest in this respect.

All these children had great difficulty in reading—some could not recognize letters, words or figures with certainty; some could read simple words and knew all the letters and figures well. No child was retarded less than four years in reading. Even the children who could read best had great difficulty in writing and spelling words. It was found in the experimental work that these children failed to retain what had actually been taught them. The tests calculated to show this fell into three groups: 1. Rapid visual discrimination of forms together with the ability to retain these without undue repetition. The forms closely resembled each other or differed only in the arrangement of their parts; for example, ran, ram or god, dog, saw, was. 2. A similar rapid and easy discrimination of sounds. 3. The possibility of establishing readily an association between a given form and a given sound. The experiments are arranged in three groups to suit these aims. The results are compared with those of a group of children able to read of equal age and mental ability. The exact number, age and intelligence quotients of these children are not given.

The experiments are carefully explained and the results tabulated. After each tabulation certain inferences are drawn which serve as a basis for the conclusions. Some of the tests appear to the reviewer to be rather stiff, and in many of them the control readers apparently had as much difficulty as the subject readers did in their successful accomplishment. Particularly difficult were the experiments used to test the power of making auditovisual associations. In these, a given form was exhibited for two seconds (hieroglyphics or Greek letters or shorthand symbols) and a common name given it by the examiner, then the children were asked to write the associated names after the examiner reversed the order of the name association for the various forms. Even more difficult than this was the experiment associating words and Greek letters. These visuo-association tests led to the following conclusions: 1. Nonreaders as a group make associations between dissimilar and characteristic forms and words with meaning as readily as do the readers. Their difficulty, however, is increased at a rate in excess of that of the readers, with the increase in similarity between the forms and sounds presented. 2. In all cases, the ease with which association is made between a form presented visually and a given name depends on the nature of these. 3. The facility of association is greatest when they are readily distinguishable and have a meaning apart from that inherent in their actual presentation; in other words, they must be symbols and must have the ordinary symbolic significance which

comes from their common interchange and use in the general environmental experience. It seemed to the reviewer that some of the author's tests lacked precisely this essential.

It is now possible to estimate the bearing of the experimental work which has just been described on the theories commonly held as explanatory of the condition having as its most obvious symptom failure to read or to learn to read. Three points are important.

1. It is clear from the facts: (*a*) that nonreaders are found among children showing all degrees of intelligence; and (*b*) that the degree of failure in reading, at least among normal children and high-grade defectives, shows little correlation with the degree of so-called general defect, and (*c*) that the underlying inability to read is to a certain degree specific in nature. The idea that deficiency in reading power is always an indication of a deficiency of a more general kind, is, therefore, by no means supported by the psychologic facts. Of course, the condition known as general defect is more frequently accompanied by loss of power in this particular, as in all other abilities, in these children than in children of normal mentality.

2. Yet there is nothing in the results of the experiments to indicate the existence of any such region as a visual-word center, the absence of, or injury to, which will make the visual recognition of words impossible. The defects found are not so strictly localized as such a hypothesis would demand, for the word-blind individuals reveal special difficulties in dealing with material other than words. Further, the implication of this theory that ability to read depends on the power to store up images of words has no psychologic support; the recall of images is not in question.

3. The theory that the experiments do support is that word blindness is only one aspect of a more general, yet still in itself specific, defect in either the visual or auditory regions or in both. All the nonreaders examined showed a reduction of the normal power in dealing with forms visually presented, especially when these forms were very much like each other, their defect being shown most definitely in their failure to remember such forms. Further, certain nonreaders showed corresponding defects in the auditory region—they could not readily discriminate or retain similar sounds. Some of the worst cases had defects of both kinds. Taking the group of nonreaders as a whole, however, no correlation could be found between auditory and visual ability; that is, these defects appeared also to be specific, although occasionally found in one subject.

Certain experiments indicate that the cause of the failure to associate, as well as to retain, sounds and forms, lies to some degree in this primary disability of the auditory or visual regions, resulting as it does in the failure of the forms or sounds presented to gain any meaning. Whether there is also a failure in primary retention, showing itself in the failure to form memory images to a normal degree, is not known. An inquiry into the use of imagery, depending as it does on the introspection of the subject, is difficult with defective children. Many of them used visual imagery in other matters, but they may, nevertheless, have been unable to visualize forms which had no meaning for them.

The author has done an immense amount of ingenious, careful psychologic investigation. Her investigation was made along lines calculated to yield just as good results in clinical cases, particularly the aphasias, which have hitherto been approached, it seems to me, in the wrong way.

OSNATO, New York.

Society Transactions

AMERICAN NEUROLOGICAL ASSOCIATION

Forty-Eighth Annual Meeting, Washington, D. C., May 2-4, 1922
ADOLF MEYER, M.D., *President*

VENTRICULAR RADIOGRAPHY IN THE DIAGNOSIS OF BRAIN TUMORS. DR. WALTER E. DANDY.

A series of slides was shown, demonstrating the localization of tumors in the various parts of the brain by cerebral pneumography. Tumors anywhere producing symptoms of intracranial pressure should be localized in this way. If there are localizing symptoms there is no necessity for the injection of air. The dangers of the procedure were indicated and emphasized as serious and only to be assumed by one with experience in intracranial work; but it was pointed out that these dangers were small compared to the dangers of futile operations in attempting to find a tumor not previously localized. The indicated treatment for any brain tumor is a precise localization, and an accurate treatment rather than one of guesswork.

The extirpation of gliomas in the cerebral hemispheres and cerebellum was briefly outlined. The treatment consists of extirpation of the tumor together with a zone of healthy brain tissue around. The ultimate results of such treatment must await the verdict of time. The operation itself entails only a small mortality and there is no mental or physical defect produced which was not previously caused by the tumor's growth. Such resections, of course, are restricted to silent or nearly silent areas of the brain and are not indicated in the left temporal lobe.

DISCUSSION

DR. ERNEST SACHS, St. Louis: I have followed Dr. Dandy's work with great interest and have used his method since 1918. In my limited experience with the method, there have been few cases in which it has been of any value.

I reviewed my last fifty cases of tumor and found that I had exposed the tumor at operation in 70 per cent. of the patients. There is a great discrepancy if Dr. Dandy is able to localize every tumor with this method. However, I note he states that, in his experience, but 50 per cent. of the tumors can be diagnosed neurologically. Since he has pointed out that the method is of real danger, it seems that we ought to emphasize the importance of very careful neurologic study, with a view of making use of this method only in those cases in which localization is absolutely impossible.

I am inclined to take exception to Dr. Dandy's statement that the removal of such enormous areas of the brain can be accomplished without shock to the patient or without mortality. In my experience, such a procedure has been attended by considerable mortality. One other point which we shall have to determine is whether life is prolonged by a palliative rather than an operative procedure in the case of an infiltrating tumor.

DR. ISRAEL STRAUSS, New York: I believe all neurologists feel that any method which will assist in the localization of brain tumors is of great importance. All of us probably have had difficulty in differentiating between a

tumor in the cerebellum and a tumor in the frontal lobe. Dr. Dandy's method would offer the hope of surmounting that difficulty. If a tumor in the frontal lobe showed an involvement of the ventricle, there would be no hesitancy in discarding the possibility of a tumor in the cerebellum. Likewise, if we suspect that a tumor is in the cerebellum and find no involvement of the lateral ventricle and no internal hydrocephalus, it might aid us to reach the conclusion that such a neoplasm is present in that posterior fossa.

Regarding the operation on infiltrating gliomas, a neurologist must not be too conservative in the presence of these growths. I recall an instance in which the neurosurgeon removed practically the entire hemisphere of a patient, who afterward died. It is true that we found this tumor going over to the opposite side. This was a "chordotomy" of the cerebrum. If any of us were asked our choice as to whether we wanted to live with an infiltrating glioma or be relieved by a cerebral "chordotomy" we probably would choose the latter.

Dr. M. Allen Starr, New York: There are two methods of approaching this subject. The first is the neurologic. We need aid in operating on brain tumors because those who have had large experience are less encouraged at the present time than they were twenty years ago. The larger proportion of brain tumor operations are failures. The second way of approach is the surgical. We have something offered to us by Dr. Dandy which is epochmaking, if it can be executed properly.

Dr. Harvey Cushing, Boston: We all differ in our degree of conservatism about disease and the methods which are justifiable for purposes of diagnosis and treatment. I wish that Dr. Dandy would state specifically the number of tumor cases he has investigated in this manner. I believe that he has tended to be overenthusiastic about the procedure and to belittle the risks. He speaks of 300 cases in which he has used the method, and I hope he will tell us how many of these actually proved to be tumors that could not have been localized by the usual neurologic studies.

Dr. Dandy reports only three deaths in this series which contained, if I understood correctly, 100 tumors which could not be localized by other means. The subject was under discussion at a recent meeting of the Neurosurgical Society, and I should judge from the returns that the mortality in other hands has been very much higher, though that may be explained partly by our inexperience. Moreover, the information which has been given by the plates was perhaps not as dependable as Dr. Dandy has led us to hope it might be. Time will settle these matters, as it has with the use of the roentgen ray in localizing and diagnosing lesions of the pylorus, for example. We gradually have learned what filling defects are, and so we may learn also what filling defects are in the case of the ventricles. However, I am quite sure that, as we see such cases earlier, it will become even more difficult than it is to recognize cases in this way, because a tumor, unless it happens to arise in the ventricle, must attain considerable size before it can change the configuration of the ventricles in such a way, or to be of localizing value.

My small experience, together with what I have gathered from others, leads me to believe that the risks are no less than those we assume in doing a lumbar puncture and withdrawing fluid in the presence of a cerebellar tumor. We believe that it is hazardous, though we perhaps may have overemphasized them. One cannot withdraw fluid from the ventricles without dislocations which may be serious and may accentuate greatly preexisting pressure symptoms; nor do I understand how these symptoms can be set aside by the

reinjection of fluid. Certainly, if one had respiratory difficulties after drawing off fluid by lumbar puncture, he would not venture to attempt a replacement of the fluid.

I hope that Dr. Dandy will give us additional information in regard to his view of replacing the air by fluid, if hyperthermia supervenes. If there is any way of checking hyperthermia, I shall be glad to know of it.

In Dr. Dandy's enthusiasm, he has led many to believe that a shortcut to the localization of brain tumors has been discovered and that all such patients should be subjected to it. I may be unduly conservative, but I have grave doubts of this. If the procedure has been so successful in Dr. Dandy's hands, it is incumbent on him, for the sake of others, to be less general and more specific in regard to removing tumors that could not otherwise have been detected and removed, or those which may have been shown by the method to be unsuited for operation. Even if this should represent only a small percentage of brain tumors, instead of the majority he claims, we must eagerly accept the procedure as a very important contribution.

Dr. Bernard Sachs, New York: I have been thoroughly impressed with the dangers and limitation of the method. It should be applied only in cases in which the ordinary neurologic examination fails to disclose the probable site of the tumor. Dr. Dandy has emphasized that the procedure has to be applied with extreme care and that the surgeon should be present at the time the roentgen-ray plates are applied to the head.

Dr. Lewis J. Pollock, Chicago: I should like to ask Dr. Dandy whether any extensive studies have been made on normal lateral ventricles and whether any definite study has been made on the influence of lesions in certain parts of the brain in specifically changing the mechanics of the ventricular system. Dr. Loyal E. Davis and I have studied a number of normal brains fixed in situ; and, although we have had only thirty-six cases, I can readily see that there are a great number of variations which should be definitely noted. This is particularly true in reference to the posterior horns, which in some instances are exceedingly asymmetrical, very often quite blunt, so that one may be likely to misinterpret from a ventriculogram of such a horn, as impinging tumor.

Dr. Charles H. Frazier, Philadelphia: I believe that the discussion on this subject will be more interesting a year hence, when we shall have had a larger experience and shall be able to present statistics more accurately with regard to the helpfulness in diagnosis, the risk of the method and the increased percentage of the cases in which tumor may be removed radically. As Dr. Cushing has said, we have been handicapped by the lack of specific information in regard to technic. As to the propriety of endorsing what might be said to be a blocked section of brain tumors, comparable in a way to a blocked section of tumors of the breast where one would block out the mammary gland, the underlying muscle and all tissue adjacent to the tumor or possibly involved by it, my opinion is that this should be regarded as an extremely hazardous procedure. I should be disposed to look on these deepseated infiltrating gliomas in which the definition is not sharp, in which the tumor tissue shades off into the neighborhood, as inoperable from the standpoint of eradication and of making a rapid recovery. I should be in favor of resorting to removal by decompression, followed by radium therapy by direct implantation and later by the indirect method.

Dr. Charles A. Elsberg, New York: I have done about forty ventriculographies, a number in hydrocephalus of infancy and childhood and a number

in brain tumors. In two cases of the latter, the ventriculogram was of great aid in localizing the growth. One of the patients was a young woman. It was not certain whether she had a cerebellar or frontal tumor, and the ventriculogram contributed considerably to our arriving at a correct conclusion: that the patient had a cerebellar tumor.

I have been very conservative in making ventriculograms on account of the dangers of the procedure; but I have been fortunate in not having had any deaths, although in one of my earliest patients there were very severe symptoms after the air injection. In one of the institutions in which I am working, about 90 per cent. of brain tumors were correctly diagnosed and localized before the operation, during the past year.

I should like to know Dr. Dandy's point of view regarding the following question which concerns the removal or attempted removal of large infiltrating growths: Presuming that an attempt to extirpate a large infiltrating tumor is justified, how is one to know after beginning whether the entire growth with surrounding brain can be removed? It is impossible to foretell how large a tumor is. If one is dealing with a cystic glioma the size of which has been determined by air injection and radiography of the air in the cyst, a fairly correct idea of the size of the growth is obtained. It is an entirely different matter when one is dealing with a solid infiltrating tumor whose extent cannot be judged. The excision of small infiltrating growths, especially if they lie in or near the cortex, is of course justified.

Dr. Howard C. Naffziger, San Francisco (by invitation): I have had experience with approximately forty cases since the latter part of 1919, of which about fifteen have been cases of tumor. I have been fortunate in not having any deaths and only one severe reaction. Possibly because of my lack of ability in interpretation, I have not received help in localizing growths which lay between the foramen of Monroe and the foramina of Magendie and Luschka. The cases in which I have received aid have been those in which there has been some uniform enlargement, which caused deformity of the lateral ventricle.

I agree with Dr. Strauss that one does not explore a normal cortex with much feeling of security unless there is definite evidence that there is a lesion beneath.

Recently, I had a case of endothelioma such as springs from the base of the middle fossa, in which the inferior horn was obliterated and a portion of the superior horn reduced to a narrow canal on the right side. I believe that in less than half of the cases I have received help.

Dr. Colin K. Russel, Montreal: We want to know what actual risk is entailed and the reasons therefor, so that danger may be avoided, if possible. Dr. Dandy has reported several cases, but until we have actual statistics we must take the risk blindly.

Dr. James B. Ayer, Boston: I agree with Dr. Russel that even those who claim a large percentage of accurate diagnoses made by clinical examination will admit that there is still a residuum of cases in which any measure which will bring light will be welcome, and such a measure is pneumoventriculography. To my mind the discussion turns chiefly on the question of the safety of the procedure.

As I understand his technic, Dr. Dandy inserts a needle into the ventricle, draws off a considerable amount of fluid, and then replaces it with air. In such a procedure, there can be no doubt that a rapid, perhaps sudden,

reduction of cerebral pressure occurs, followed by a rapid increase of pressure which may be greater or less than that originally present. It seems to me that the ideal to be approached would be substitution of air for fluid, with no change of pressure at all. If that could be done, dangers incident on change of pressure could be eliminated.

Recently Dr. Mixter performed pneumoventriculography with a two-way needle which I had made experimentally as follows: Two lumbar puncture needles were soldered together in order to make one needle with two bores. To one was attached a glass manometer which ran up to about 350 mm. the height, being varied, however, by means of rubber tubing between the needle and manometer. The upper end of the manometer was bent over to allow fluid to be collected in a test tube. The other needle was connected with a syringe. As air was introduced from the syringe, fluid was slowly forced out, the whole procedure taking place under the same pressure as originally found in the ventricle. It seems to me that modifications of the procedure along such lines should make the technic safer.

Dr. Harry Hyland Kerr, Washington, D. C. (by invitation): In my experience with twenty cases of ventriculography, I have had no deaths. In two, the procedure helped materially, though neurologic examination gave a presumptive localization. In two cases, I was misled. In both of these, the roentgen-ray evidence pointed to posterior tumor. I should like to ask Dr. Dandy whether the normal variation referred to by Dr. Pollock has ever caused him to make a negative exploration.

Dr. Adolf Meyer, Baltimore: A series of observations that I made years ago in current necropsies corroborates Dr. Pollock's findings that in the occipital lobe we must use caution not to consider any asymmetry of the posterior horns alone as an indication of any disturbance in the structure of the brain, because asymmetry occurs exceedingly often. Therefore, in that region at least, there is very definite necessity for additional symptoms, and we are able to obtain those, because the occipital lobe after all is one of the most sensitive areas on account of the visual field interferences.

Dr. Charles E. Dowman, Atlanta, Ga. (by invitation): I have used Dr. Dandy's method in all suspected tumor cases when neurologic examination failed to give an accurate localization. It has been of value in two respects; namely, in localizing cerebral tumors and in excluding tumor. One tumor of the anterior part of the corpus callosum involving the third ventricle was accurately localized by the method. This unfortunately was inoperable, proving to be a rather large glioma, which was confirmed at necropsy. Another case was one of frontal lobe tumor in which there was a certain element of doubt as to the localization. It was accurately located by air injection and later was removed with success.

There were four or five cases of questionable tumor, cases in which there were papilledema and increased intracranial pressure, with no localizing findings or symptoms whatsoever, in which air injection seemed to exclude tumor, in that we obtained fairly normal appearing ventricles with no filling defects.

I believe that the method is more or less dangerous, although personally I have had no fatalities. I have always accompanied the patient to the roentgen-ray room, have manipulated the head myself and have immediately withdrawn the air after the examination. I have noticed that in inserting the needle in order to withdraw the air, a large amount of serosanguineous fluid escapes in addition to the air. This would seem to indicate that the air acts as an irritant and produces an oversecretion of ventricular fluid. I

wish to emphasize the importance of withdrawing this fluid and the air immediately after the roentgen-ray study. I believe such a practice will prevent to a large extent the element of danger.

DR. DANDY, Baltimore: I did not mean to give the impression that this was not a dangerous procedure, for I have tried to emphasize the dangers in every publication. In fact, the danger is so great that, even with my enthusiasm for and confidence in the method, I have often wondered whether it has not done more harm than good because of indiscriminate use without judgment.

The procedure is one which must be handled with great caution, and the surgeon must be willing to observe the patient with care; for the dangers can be eliminated by very close after-care of the patient.

A few years ago, we analyzed a series of cases from the hospital which had been thoroughly studied. We are fortunate in that we have had the experience of Dr. Thomas in practically all of the brain tumor cases and in some that of Dr. Meyer. Therefore, in giving the statistics of 50 per cent. localization of brain tumors, there are no apologies due because many of those cases were verified only after two and sometimes even three operations.

If one's experience is largely with pituitary tumors or those which are self-localizing, the percentage of necessary uses for ventriculography would be very much less. I am sorry that I have not the accurate statistics, but I can assure you that the percentages which I have given are correct.

I can readily see why everyone does not obtain results from the use of the procedure; for one can be misled easily in the interpretation of the plates, unless he has had sufficient experience in differentiating the phantom from the real shadows, and unless he knows every step taken in placing the patient's head correctly. The results which I have obtained will substantially bear out the successful use of the method. If one can localize a tumor as small as a hickory nut, 7 cm. below the surface of the brain in a lateral ventricle, or precisely locate a tumor the same size in the third ventricle, and remove them at operation, it is sufficient proof that there is objective evidence of the merits of the procedure.

MENTAL HYGIENE. By STUART PATON.

The permanence and progress of civilization depend primarily on success in educating the public in questions of hygiene, both physical and mental. It is foolish and disastrous to try to teach the two divisions separately. The old superstition that the body and mind should be considered independently should not be perpetuated. A campaign to prevent physical disease would be far more effective if it were associated intimately with mental hygiene.

Mental hygiene can be of great assistance in pointing out the kind of mental processes favorable for taking the first step in all sciences, i. e., the ability to draw distinction between appearance and reality. The greatest obstacles today preventing improvement in public health service are: obsessions, fixed ideas, prejudices, beliefs in mysticism and various other forms of irrational beliefs. Probably these forms of alienation are responsible for conditions that cause more deaths than all the infectious and contagious diseases combined.

Until mental hygiene plays a more important rôle in organizing the campaign to improve public health conditions, the effectiveness of physicians' efforts in this direction will be very much less than they should be. To

arouse people to the necessity of improving personal or community hygiene and of getting rid of flies, mosquitoes and other disease-bearing insects is first a question of mental hygiene.

There is another and more important reason for asking assistance of mental hygiene in an effort to increase the effectiveness of public health campaigns. Mental hygiene is a very effective means of diminishing the chance of war. It assists people to recognize early in their development the kind of mental processes involved in belligerent attitudes, or those that may easily become belligerent. The chief hope for the future is mental hygiene, as a means of preventing the form of insanity which leads to aggressive war. If not successful in preventing another war, then the public health campaign will be of little use to civilization.

Scientists who are familiar with progress made in the art of destroying life, since the armistice, say that one more world war will permanently cripple our civilization. Unfortunately, it cannot be said that we have been as intelligent in preparing for peace as for war. No organization of scientific men to establish and maintain peace exists today that is comparable in extent or effectiveness with the organization effected to wage war. We showed more organized intelligence in waging war than in preserving peace or fighting disease.

During the war, the intimate relations between body-mind problems were forced on our attention. Now we have relapsed into the old indifference. Attention has been directed persistently to the old superstition that interest in mental hygiene should be cultivated after physical hygiene is firmly established. One reason for this assumption is that the modern physician is trained almost exclusively in analytical methods. He does not realize that synthesis is as important as analysis. It is of immense practical as well as philosophic importance to the world that physicians realize that, as Dewey has said, it is "almost a truism that knowledge is both synthetic and analytic; a set of discriminated elements connected by relations." There is plenty of scientific curiosity in regard to analysis about the function of parts, but not about synthesis or human behavior. We study the action of separate organs but we should also study the machine as a whole—its activities as they are represented in behavior.

DISCUSSION

Dr. Foster Kennedy, New York: Dr. Paton's generalizations are the result of his desire to synthesize. He should analyze his generalization and explain the meaning of the words "mental hygiene." We understand how a community can be clean in a sanitary and physical way and know the mode of attack. I doubt if many have a clear understanding as to how to start psychical community cleansing. Undoubtedly, it must be accomplished by education, and the physician should be an educator; but I think Dr. Paton should state as precisely as possible the lines along which that education should go.

Dr. Paton has stated that mental hygiene, properly applied, could stop war. Is it not true that one of the causes of war is that every man who has been through one afterward forgets the unpleasant part? One never sees three old soldiers together, talking of their campaigns, without realizing that they are giving the impression that they had a splendid time. That impression is passed on to the youth of the generation and each generation must have its war in order to see what it is like. I believe that if those who were

uncomfortable for a few years in France were to make it clear that war is an exceedingly muddy, bloody affair, instead of being amusing, we might do something to correct the bias of the oncoming generation.

It is a little difficult to see what more can be done for this specific end. Every child of course ought to be told at an early age that every act he undertakes carries with it reward or punishment; and that every issue ought to be dealt with instinctively. It should be possible to inculcate, at an early age, a decent regard for the other man's rights and point of view. If Dr. Paton can tell us how to make a living force of a good system of ethics (Christianity has scarcely failed but has never been tried), then possibly he may succeed in a campaign of mental hygiene to prevent future war. The root of the matter is character and not intellect.

Dr. Joseph Collins, New York: Probably the members of the Association agree with every statement that Dr. Paton has made, but his communication disappoints me because it is not specific. There is no one who has more native ability and talent and time to outline and develop a scheme, than Dr. Paton. He knows that we agree with him as to the urgency of this matter. Therefore, I construe it to be his duty to present a scheme rather than a plea.

Dr. Paton has said that it is much more important to teach men how to think than what to think. Is there any way of teaching men how to think? Is there a psychologist who has formulated a plan or a definite rule as to how to think? Does not the organism, constituted physically and chemically different, think in different ways?

It is an individual reaction whether you will agree with Dr. Paton that a campaign of mental hygiene will eliminate war. The "mental hygiene" that Dr. Paton has in mind may "cure" man of his cravings for superiority and power, and if so, it may prevent wars. I do not believe that it would; nor do I believe that it is our duty as physicians to try to eliminate war.

Nothing has brought us into such discredit as our medicolegal conduct, because we have never been willing to take the time to teach the public the meaning of personality and behavioristic psychology. There is not the slightest effort being made to convey to the public that there are as many different types of psychologic, mental and emotional reactions as there are different types of facial lineament. We do not make the smallest endeavor to point out to great organizations and to the public in general that the paranoic type of mind is just as prejudicial before it displays symptoms of mental unbalance as it is afterward. We do not make the slightest attempt in our conjunction with pedagogues to make a differentiation of the different forms of mentality in their budding. These are all problems of mental hygiene. We do not do it because (1) we do not construe it to be our duty; (2) there is no incentive for doing it, and (3) there has never been any incentive or force from behind by the profession or force from in front by the public.

Up to the present, we have been content to instruct, to enlighten, to orient; we must arbitrate and judge as well; we must get our "feelings" into the case; we must be partisans. That is what has brought such infamy on us as expert witnesses. We do not take the verdict of the jury with the equanimity that Socrates displayed after his fellow Athenians had judged him; nor, unfortunately, do we appear to be willing to instruct, which he did all his life. But finally we shall content ourselves in so doing, when the insensate sense of our own dignity and importance has been eradicated and destroyed.

The aim of mental hygiene is to prevent or delay the development of so-called functional nerve disorder, to thwart potential mental disease, to equilibrate and aid the growth of every individual's instinctive, emotional and intellectual equipment, but especially those who are handicapped by inheritance or accident. To accomplish this, we must have a plan, for it cannot be done haphazard.

Dr. Bernard Sachs, New York: I am in sympathy with any movement for the improvement of the mental condition of the people of this country. Dr. Paton has endeavored to develop altogether too large a program, and he will completely fail of any success in this movement unless he limits it.

We have all believed that the idea of mental hygiene was not so much to improve the intellect as to prevent the development of unfortunate conditions of intellect. I do not agree with Dr. Paton that it is our function as physicians to teach the public how to think. The large majority of people do a considerable amount of thinking. Educational institutions are concerned with the problem of teaching persons how to think.

There are many other problems in the world that are of greater importance, and as far as making the mental hygiene movement responsible or in any way sufficient to influence future wars, I agree with Dr. Collins that we need not assume that enormous responsibility. I believe that there is need of psychiatrists and alienists in this matter, but there is also necessity for common sense men and women.

Dr. Edward B. Angell, Rochester, N. Y.: Ouizon, in his History of Civilization remarks that "common sense is the genius of humanity." If we could eliminate the word "mental," as Dr. Paton is endeavoring to do, we should be able to teach the important points in the development of mind in a better manner.

The primary requisite, in my opinion, for the development of mind is a well-developed brain, which we can obtain by proper training; and a well-balanced brain will give common sense, which is a primary requisite if we want to make mental hygiene of value to the public at large.

Dr. Colin K. Russel, Montreal: When one considers the history of the world and the disasters that have occurred at various periods, completely destroying the existing population, I sometimes wonder whether the present civilized world is not rushing on to its own destruction, and it is a question whether Dr. Paton's proposed campaign is not too late. In the report of the psychiatrists of the United States Army, one finds that more than 75 per cent. of the young men of this country (and probably this is true in other countries) had the mental age of 14 year old children, and more than 66 per cent. had the mental age of 12 year old children. If one questions the men of this country, the answers will be that of a boy 12 years of age, and this is the voice of the majority of voters. In the United States, with its hundred million population, about four million have real intelligence, are fitted to be leaders.

Dr. William A. White, Washington, D. C.: I think that it is too much to ask Dr. Paton to present a finished, well-worked out, thoroughly practical scheme for the proceeding which he advocates. We may have some moral responsibility as physicians, or if not we perhaps have some responsibility as citizens to bring to bear upon some such scheme as this.

As an administrative officer, I have never seen a situation that was so hopeless that it could not have been made better. If 75 per cent. of the people have intellectually the minds of 13 year old children, I am satisfied that there is some way of dealing with that problem.

DR. C. MACFIE CAMPBELL, Boston: It is very difficult to eliminate words and to think in terms merely of concrete facts, actual reactions. There is not much difficulty in knowing what is meant by the term "mental hygiene." As the term hygiene has already been trademarked by those who have been working with infections and nutrition, we are compelled to use another term. Social hygiene is used by those who have found that public opinion prevents them from talking about venereal disease, so that we have been barred the use of that term. Therefore, I believe we have adopted in mental hygiene a term which is perfectly adequate for our practical purpose.

Psychiatry deals with the health of people, taken not merely as a problem of symptoms, but in relation to their adaptation to situations in the problems of life. In regard to these problems, the first important one is with regard to the tremendous number of gross mental disorders as ordinarily understood, the hundreds of thousands of insane people who are in the United States. We have assumed too fatalistic an attitude with regard to these disorders. If a person with a mild depression is mildly suspicious or is beginning to have disturbed sleep and peculiar impulses and odd speech, the common attitude is concealment. We should institute treatment at the earliest stage, but that can be accomplished only by wide community education.

In the average community, there are not the efficient facilities for treating an incipient stage of a mental disorder. The majority of practitioners have not been trained in the medical school to examine the patient and his reactions to his environment. After a thorough examination, including that of the central nervous system, and finding no definite cause, the practitioner states that the patient has "neurasthenia." Probably it is weeks, months or years before the patient with a mental disorder finally obtains adequate treatment. Is there, in every fair sized general hospital, an attempt to see that, in a special department, that aspect of the patient's disorder is observed? In medical schools, every medical practitioner realizes that it is part of his job, with regard to disease, to pay attention to emotional reactions, instinctive reactions and situational difficulties. We must be positive that there are proper opportunities for the early treatment of disorders in the state hospitals. As such problems begin in childhood, we should appoint school physicians and nurses who are alert to the necessity of giving attention to the emotional disorders of the child. This means that the teachers are not untrained and irresponsible individuals who have had a meager education, but in their training schools they have had impressed on them the necessity of recognizing these factors.

By laying adequate stress in the universities, in the medical schools, on an adequate department of psychiatry; by seeing that in all the health work of our state and municipal departments the foregoing factors are recognized; by seeing that in all our nursing organizations the nurse is trained not merely to look after individual organs but also to care for sick people, we shall be dealing immediately and in a practical way with the problems of the actually existing disorders of the community

DR. HUGH T. PATRICK, Chicago: I am most sympathetic with Dr. Paton's comprehensive and ambitious program. I am also exceedingly sympathetic with Dr. Campbell's program, which may be municipal, may be in relation to the commonwealth, and might be national in its scope. Part of our responsibility, aside from that to the public at large, either as physicians or as citizens, is our responsibility to the patient, to the patient's relatives and to the practitioners who bring these anomalies of behavior to us. Our duty is to help to educate the patient and the relatives and friends of the patient, and

to educate the medical profession. Dr. Paton's program is a very small, perhaps an entering wedge, which I hope will be realized ultimately, but I conceive it to be a serious responsibility. Of course, it involves (1) an adequate understanding of these peculiar behavioristic anomalies; (2) the capacity to impart to the general practitioner and to the lay mind a clear and concise conception of it, and (3) the time and trouble constantly to practice it.

Dr. Joseph Collins, New York: If anything is to result from this discussion, Dr. Paton should tell us whether he agrees with Dr. Campbell, whose conception of mental hygiene is that we may eliminate the five or ten millions of potentially insane in this country. Dr. Paton's conception of mental hygiene does not seem to be the same, for he has brought in the entire field of education.

Dr. Paton, Princeton, N. J.: I agree thoroughly with Dr. Campbell and think that he agrees that education assists an individual to adjust his life. I have brought this subject before university presidents, professors and school teachers and should like to tell Dr. Collins that he is the only person who has disagreed with that view.

CHICAGO NEUROLOGICAL SOCIETY

Regular Meeting, April 20, 1922

Lewis J. Pollock, M.D., *in the Chair*

A CASE OF BILATERAL SERRATUS MAGNUS AND UNILATERAL RADIAL NERVE PARALYSIS. Dr. G. B. Hassin.

Bilateral serratus palsy is a rare condition. Only two cases have been recorded (by Bramannin, 1888, and Sperling in 1891). Bramannin's case proved to be one of progressive muscular dystrophy, Sperling's of bilateral brachial plexus paralysis. It is almost generally admitted that a bilateral serratus palsy is a manifestation of progressive muscular dystrophy (scapulohumeral type of Erb).

The patient presented, 23 years of age, a repairer of typewriting machines, consulted me for weakness in the left wrist, inability to extend or abduct the left thumb and to extend the left index finger. The weakness was first noticed about three years ago, was gradually growing worse, but did not interfere with his work.

Examination revealed an oblique position of both scapulae with the lower angles projecting and approximated to the vertebral column; marked "winged" scapulae when the patient extended the arms at right angles to the body; inability to raise the arms to a vertical position unless he threw them up; atrophy of the pectoral muscles, especially the right; atrophy of the left supinator longus; slight drooping of the left wrist, which he extended with difficulty and with marked ulnar abduction; inability to extend the left index finger and thumb; absence of atrophy in the small muscles of the hands; absence of atrophy in the entire right upper extremity; asymmetry of the abdominal muscles with displacement of the umbilicus to the right and a mild scoliosis with curvature of the spine to the right.

The electrical examination revealed no response to the faradic or galvanic currents on the part of both serrati, lower third of the trapezius (both sides) and pectorals, but a good response in the muscles of the forearm and hand of both sides; the anodal closure contraction was somewhat stronger than the cathodal, especially on the left. The tendon and periosteal reflexes in the upper and lower extremities were brisk, without a Babinski sign. The abdominal reflexes were present. Sensibility was normal throughout. The lower extremities showed no muscular or other abnormalities. The pupils, mentality and genito-urinary organs were normal.

The patient thus showed a peculiar combination of scapular atrophy with paralysis of some of the muscles supplied by the left musculospiral nerve. Such a combination is rather unique and entirely foreign to the dystrophies, some features of which this case possessed. It is remarkable that the very muscles the patient used in his occupation showed the atrophy most. He was left handed, and began his present work at the age of 17. He had to move from the shelves a great number of heavy typewriting machines; in carrying them he pressed them closely against the chest and had to lift them to put them back. In using tools he made innumerable turning movements with his left hand and forearm and he used his left thumb and index finger in handling such instruments as screw drivers, etc. It is quite probable that the constant strenuous muscular efforts led to the atrophy, which is thus most likely of the occupation variety.

DESENSITIZATION AS A METHOD OF TREATMENT IN EPILEPSY AND MIGRAINE. Dr. Joseph L. Miller.

The accidental discovery that epilepsy and migraine are relieved by the intravenous use of various foreign proteins and by peptone has led to the view that both of these diseases may be anaphylactic in character. There is considerable evidence to support this view.

Asthma and hay-fever, recognized sensitization diseases, are both definitely hereditary. Heredity is evidenced in 90 per cent. of cases of migraine and 20 per cent. of cases of epilepsy. Their frequent temporary, and occasional permanent, disappearance after severe acute infection might be accounted for by desensitization. Frequently, bronchial asthma disappears during pregnancy; attacks of migraine, as a rule, are less frequent, or entirely absent, during pregnancy; epilepsy is often favorably affected by pregnancy. Anaphylactic shock in animals is always associated with eosinophilia, and Gansler reports eosinophilia of from 5 to 15 per cent. in 74 per cent. of migraines. Excitement or worry is an important factor in exciting migraine or epileptic seizures, and we have an analogue in nervous asthma.

We know little of the nature of the sensitizing agent—perhaps as in asthma a great variety of proteins may be responsible. Gowers refers to a patient who always had an epileptic seizure after eating beef, although other meats could be taken with impunity. If the manifestations are really anaphylactic we must assume that desensitization, or an antianaphylactic state, can be developed by nonspecific agents. In support of this assumption is the demonstration by Dale, Krause, Biedl and others, that animals sensitized to horse serum may be partially desensitized by peptone.

There are some interesting clinical observations on the results of treatment with protein. Spangler's use of snake venom in epilepsy was one of the earlier

observations. Crocket's results obtained by giving epileptic patients tuberculin are most interesting. Boehnstadt's treatment of 100 patients with migraine with a placental extract is suggestive in the results obtained.

Drs. Thomas, Raulston, and I have treated eighteen patients with migraine by intravenous injection of from 5 to 20 minims of a 5 per cent. solution of Armour's peptone, with great relief in all but four. There is little danger of anaphylactic shock with peptone given in such small amounts, and we have never observed any untoward results or febrile reaction, provided the peptone solution has been sterile.

POSTENCEPHALITIC MENTAL DISORDER; A CASE FOR DIAGNOSIS.

Dr. Clarence A. Neymann.

A girl, 13 years old, was admitted to the Cook County Psychopathic Hospital, March 16, 1922, having been referred to this hospital by the Illinois Institute for Juvenile Research. They gave us the following history:

The patient was normal until an attack of epidemic (lethargic) encephalitis in November, 1920. She was at St. Luke's Hospital for five weeks. Since that time she has not been able to get along and has practically drifted from one institution to another. She was at the Wesley Hospital, the Detention Home, St. Mary's training school, the Mary A. Club, the House of the Good Shepherd, the Detention Home, St. Francis Hospital, Evanston, the Detention Home, the County Hospital, the Detention Home, and finally reached the Cook County Psychopathic Hospital.

Her mental age was 10 years with an intelligence quotient of 83.3 in January, 1921. The tests were repeated in January, 1922, when she showed a mental age of 10 years and 2 months with an intelligence quotient of 78.3. It is thus apparent that she suffered an arrest in mental development at about the 10 year level. In the Detention Home and other institutions, the patient was very quarrelsome, bit the other children, cuffed them, knocked them down and finally put pins in the tips of her shoes and kicked them. She was an inveterate liar, extremely incorrigible and accused every one of picking on her.

Physical examination revealed the usual findings of an old encephalitis; the pupils were irregular and reacted somewhat sluggishly to light and accommodation. There was a decided enophthalmos, and the facies had a parkinsonian expression. The knee and ankle reflexes were exaggerated, especially on the left side. Babinski, Gordon, Oppenheim and other pathologic reflexes were absent. The hands were held in a typical position folded in the lap. The patient was inclined to sleep a great deal while in the hospital.

Thus the case was rather typical of a postencephalitic dementia, but the active assaults on other children have not been explained. A further psychiatric examination is interesting. This showed that she was emotionally quite indifferent to her situation; threats of punishment did not affect her, and she showed no signs of regret for her actions. She had definite ideas suggestive of dissociation of personality. She said that sometimes she felt funny as if she were changing. At these times there was something in her head which argued with her and said all kinds of words. This happened whenever she thought and this thinking went back in her head and started talking and arguing. The patient also had definite hallucinations, both auditory and somatic. She said that when she lay down to sleep at night she believed some one was talking to her; she could not say just where the voices come from or whether they were those of men or women since they talked very fast

in her head. At other times she had feelings like electricity which shot through her body. All these things had been noticed by her since she had sleeping sickness. Paranoid trends were also present, especially against the people in the Detention Home, who, she said, picked on her, teased her and treated her with every conceivable meanness.

A diagnosis of a schizophrenic reaction in a patient with a postencephalitic dementia and psychosis was made. The case is presented because of the unusual psychotic symptoms associated with organic brain disease after epidemic (lethargic) encephalitis.

Book Reviews

SURGICAL AND MECHANICAL TREATMENT OF PERIPHERAL NERVES. By Byron Stookey, A.M., M.D., Assistant Surgeon, New York Neurological Institute. With a Chapter on Nerve Degeneration and Regeneration by G. Carl Huber, M.D., Professor of Anatomy and Director of Anatomical Laboratories, University of Michigan. Cloth. Price, $10 net. Pp. 273, with 225 illustrations. Philadelphia: W. B. Saunders Company, 1922.

The treatment of peripheral nerve injuries has had a varied history, not always happy, and one of the most valuable heritages that has come to us from the great war is the advance that has been made in this field. The abundant material from the war gave opportunity for the testing of different methods in large numbers of cases and for the application of newer theories, up to then experimental, to the human nervous system. The results have been most interesting and valuable, and have proved that the nearer nerve surgery approaches nerve histology the better are the results obtained. To the neurologist, this seems axiomatic, but unfortunately it has not seemed to be so to many surgeons in the past, or they could not have devised joining operations based on tendon surgery without considering nerve fibers as individuals. The modern neurosurgeon is a neurologist, well grounded in the anatomy, histology and physiology of the nervous system. When peripheral nerves are to be treated, the neurosurgeon should be somewhat of an orthopedist as well, for much of the preliminary and after treatment is orthopedic.

In this book, the author quite satisfies the foregoing requirements. His approach is primarily anatomic and histologic. To a neurologist, the book contains much of interest. Each nerve and plexus is considered first from the point of view of its embryonic development, with many clarifying references to the phylogenetic, and these points are then collected to form the basis for surgical principals. Operations are described in detail, and considerable space is given to the expectation of results. In places, one could wish that the author's material had been larger, but this is in good measure offset by an extended review of the literature and a compilation of the experience of others. The numerous illustrations add a great deal to the book both in enhancing the appearance and in supplementing the text.

The book opens with a chapter on the anatomy of the spinal nerve, in which is reviewed much of the newer work on development. Dr. Huber's chapter on nerve degeneration and regeneration contains a wealth of material in surprisingly compact form. The reviewer does not know where in English one may find a better exposition of the subject, for the knowledge of which we owe so much to Dr. Huber's original work. The following chapters on surgical methods would interest the surgeon more than the neurologist.

Following these chapters, the author considers in detail the various nerves and nerve plexuses in which injury is likely to occur, and methods of their repair. Never does the author wander away from the anatomic and histologic features of his problem, and one is impressed that he approaches his surgery with the histologic eye. His plan of presentation is consistent throughout. A point of interest to neurologists and neuro-anatomists is the description of an anomalous nerve distribution and supply as explaining atypical paralyses and failures of operative results. The author describes and pictures in diagram many of these anomalies which have been described by others. The

chapter on nerve tumors seems somewhat sketchy. Causalgia and amputation neuromas form the subjects of the last two chapters.

From the point of view of the neurologist, this book contains much that is of interest and of value, which lies in good measure in the author's clear presentation of the anatomy and development of nerves. It should serve as an easy reference book for the anatomy of peripheral nerves and for the indications in and prognosis for nerve injuries. It is likely that the general surgeon may glean from it more than would the neurosurgeon, and one may feel glad that it will carry to the general surgeon the neurologist's point of view, which considers the peripheral nerve as a histologic structure. The general makeup of the book is pleasing, and the diction is clear and makes for easy reading.

PSYCHIATRIE DU MÉDECIN PRATICIEN. Par M. DIDE and P. GUIRAUD, Médecins de l'Asile d'Aliénés de Braqueville. Paper. Price, 20 francs net. Pp. 416, with 8 illustrations. Paris: Masson et Cie, 1922.

The various types of mental disorder are described in simple language under titles which conform in the main with those in conventional use. The style is didactic and consists largely of short paragraphs under appropriate captions which are practically definitions. The grouping of the material is founded on anatomopathologic concepts, the various clinical pictures being described as syndromes resulting from location and not from the nature of the lesion. Etiologic factors are therefore refused consideration in classification, with the consequence, for instance, that there is no group of alcoholic psychoses though the common clinical types are briefly described.

The disorders are divided into five main groups, the first two dealing with developmental defects or the results of damage in early life and the last three with the results of lesions acquired at a later period: 1. Defective mental development including idiopathic epilepsy, which is said to result chiefly from alcoholic intoxication in the ascendants. 2. Constitutional deficiencies of two kinds (*a*) pathologic constitutions such as the cyclothymic, neurasthenic, psychasthenic, hysteric, paranoid, etc., and (*b*) constitutional psychoses which develop on a basis of structural deficiency which is apparently comparable with the abiotrophy of Gowers. Here are included the manic-depressive psychoses, paranoia, paranoic states and dementia praecox. 3. Syndromes without damage to the fundamental mental framework, chiefly brought about by intoxications, include acquired neurasthenia, manic excitements, depressions and paranoid conditions. 4. Syndromes with temporary impairment of fundamental mental activity—deliriums and dreamlike states. 5. Syndromes associated with permanent damage of brain function—the dementias, focal and diffuse.

In most instances there is no attempt to define the anatomic localization of the lesion, except in the gross organic brain lesions, and the damage is merely referred to some psychologic system. Under the heading of dementia praecox the authors are more precise. The fundamental and hereditary, constitutional deficiency lies in "the nerve cells which preside over coenesthetic synthesis and instinctive vital activity," and this mechanism is possibly located in the subthalamic region, especially the locus niger. In view of the essential constitutional deficiency one wonders why "the most rational indications" for treatment should be "opotherapy, especially cerebral" and "remedies which provoke a general reaction of the organism," such as colloidal gold and nucleinate of soda.

There is increasing accord in recognizing that many of the conventional reaction pictures are not disease entities, and the authors are entitled to credit

for this effort; but it is at least doubtful whether much is to be gained by dogmatic assertions concerning syndromes in the present state of knowledge. The importance of affectivity and especially of instinctive and unconscious mechanisms is well emphasized in the opening paragraphs, and it is unfortunate, especially in view of the present trends of psychiatry toward preventive work, that more use is not made of the fact of conflict between these factors and a social mode of life. Furthermore, the emphasis on hereditary constitutional deficiencies is liable to assist in maintaining the pessimistic attitude toward mental disorders which has so long obtained. This work describes faithfully and well the end results of these still unknown deficiencies but tells little of the mechanisms involved or the means of combating them. It would seem especially desirable that such matters be given prominent place in a work designed for the use of the general practitioner, for the reason that it is on his knowledge and cooperation that we must depend largely for the practical application of psychiatry.

MALADIES DU CERVELET ET DE L'ISTHME DE L'ENCEPHALE. (Pédonucle, Protubérance, Bulbe). Par HENRI CLAUDE, Professeur a la Faculté de Médecine de Paris, and LÉVY-VALENSI, Ancien Chef de Clinique de la Faculté de Médecine de Paris. Paper. Price, 35 francs. Pp. 439, with 104 illustrations. Paris: J.-B. Bailière et Fils, 1922.

This is the thirty-second fasciculus of the encyclopedic "Traité de médecine et de thérapeutique" of Gilbert and Carnot. It begins with a consideration of the anatomy, histology, connections (six and one half pages) and physiology (fifteen pages) of the cerebellum, followed by an excellent exposition of cerebellolabyrinthine disorders. Sufficient mention of anomalies and atrophies of the cerebellum is succeeded by twenty-nine pages on cerebellar tumor and fifteen pages on cerebellar abscess. Lesions of the cerebellum in infections, intoxications and other diseases are briefly treated, and then Friedreich's disease and hereditary cerebellar ataxia receives twenty pages.

Then nine pages on diseases of the corpora quadrigemina leave the reader in a state of even greater embarrassment than this difficult subject warrants, but the section on diseases of the peduncles (twenty-eight pages) is excellent. Diseases of the pons are as well discussed as is possible in fifty pages, the symptomatology being particularly well presented and illustrated.

Only thirty-four pages are devoted to the medulla and its diseases. Then are presented "complex syndromes of the brain stem," namely, poliencephalitis, acute ataxia, epidemic encephalitis, tumors of the fourth ventricle, tumors of the pontocerebellar angle, vascular syndromes, scleroses of the midbrain and myasthenia gravis.

The entire work is decidely meritorious. Little is omitted, various opinions are freely cited, and the literature is adequately considered. What one misses is authoritative or judicial discrimination between the essential and nonessential, eventful and casual, determinative and contributory. The illustrations are well selected and the diagrams helpful, but the book lacks an index.

UEBER DIE BEDEUTUNG UND ENTSTEHUNG, DER STEREOTYPIEN. By DR. JAKOB KLÄSI. Pp. 109. Price, 30 marks. Berlin: S. Karger, 1922.

Under the general title of stereotypies have been included a heterogeneous group of movements, attitudes or utterances, recurring in identical form often

over long periods, loosely bound together by the fact that they appear to be meaningless and purposeless under the circumstances in which they occur. In this monograph, Kläsi reviews the somewhat scanty literature, details the study of a series of cases and then draws conclusions which will go far toward bringing order and precision into this obscure field. The facts are presented in simple form, and the author carefully refrains from dogmatic conclusions or fanciful speculations. The book is well written and constitutes a real contribution to psychopathology.

Kläsi reserves the term stereotypy for recurring acts or attitudes which are autonomous, do not express a mood and are not consonant with the facts of reality. They are thus essentially schizophrenic. To be differentiated from them are: (1) Repetitions which merely illustrate a belief (e. g., puffing, under the belief that the person is a steam engine) for which the title "hermenia" is suggested. (2) Repetitions which express a mood such as melancholia. These are strictly movements of expression. (3) The swaying and rocking movements of the feebleminded, and the "vocational" and other originally purposeful movements observed in organic dementia. For these the name "monotypies" is proposed.

Kläsi finds it possible to outline from his material four groups of true stereotypies: (1) defense reactions against bodily hallucinations, (2) ceremonial movements or attitudes, (3) autistic acts, and (4) residua of movements originally purposeful but now more or less distorted and abridged. Contrary to the definition of Neisser, the first three are closely related to hallucinations and delusions.

The fourth group is of special interest because those stereotypies differ from the other varieties of stereotypy and also from the monotypies which, at first glance, they resemble because they are readily influenced and altered by experimental interferences such as time and change of place. Such experiments have no effect on the monotypies, and thus they give valuable aid in the recognition of the existence of an organic lesion even when associated with schizophrenia. The character and modifiability of stereotypies are also of value in prognosis. Finally, it may be noted that the analytic studies were carried out by simple conversations, made possible by the assiduous cultivation of a state of friendly rapport with the patient, which in many instances assisted materially in therapeusis.

INSTINCT AND THE UNCONSCIOUS. A Contribution to a Biological Theory of the Psycho-Neuroses. By W. H. R. Rivers, M.D., DSc., LL.D., F.R.S. Ed. 2. Pp. 277. Cambridge: University Press, 1922.

Accepting without question the concept of human instincts and emotions enunciated by McDougall, Dr. Rivers has here formulated a tentative explanation of the various phenomena of suppression, suggestion, dissociation, and other phenomena, which play so large a part in the psychoneuroses. Such phenomena are "regressions" or reversions under stress to primitive (instinctive) modes of reaction in a manner comparable with the "devolution" of Hughlings Jackson. The experience of the author has been limited largely to the neuroses of war and for this reason doubtless the danger instincts and reactions are especially prominent while the "appetitive" instincts, so much emphasized by the school of Freud, drop into the background. The modifying influence of reactions belonging to the sphere of the gregarious instinct is also a dominant feature. Two factors are alleged to explain the great frequency

of war neuroses—stimulation of instincts by the conditions of war and diminution of the force of controlling factors as the result of fatigue, illness and military training.

The great merit of the book lies in the strikingly simple and lucid manner in which the material is presented. The greatest care has been exercised in defining terms which are often used so loosely as to be almost meaningless. The references to and comparisons with facts of physiology and biology are excellent and afford much food for thought and further study. The absence of any trace of mystic neologism and animus in the discussion of Freud's psychology is extremely refreshing, and the physiologic concept offered as a substitute for the anthromorphic "censorship" of Freud is well worth consideration. Whether or not one accepts in toto the conclusions reached, the book contains so much of really constructive merit that it should be read by every one interested in the study and treatment of human behavior.

THE PSYCHOLOGY OF MEDICINE. By T. W. MITCHELL. New York, Robert W. MacBride, 1922.

The physician who desires a short and pleasant review of present day notions concerning various forms of psychanalysis will find this book of 180 pages worth while. It adopts the attitude that there is something to be said on both sides. There is a review of the origin of present-day psychanalysis and a review of its development in the French school, led by the two pupils of Charcot—Janet and Freud. There is also a good outline of the development of the school of hypnotism. Mitchell emphasizes, among many other things, the essential differences between hypnotism and psychanalysis: one seeks to impose the personality of the physician on the patient, the other seeks to permit the patient to invoke the full content of his personality in the cure of his condition.

The style is pleasant and easy. Extremely technical terms are avoided and when inserted are well defined. The analysis of psychologic mechanisms is well carried out. After finishing, one feels "up-to-date," and able to converse with dignity and effect with any lay convert to the doctrines of Coué or Freud.

The book can be read to advantage not only by physicians but also by others interested in psychologic matters.

ÉTUDES NEUROLOGIQUES. Par GEORGES GUILLAIN, Professeur agrégé à la Faculté de Médecine de Paris. Paper. Price, 25 francs net. Pp. 469, with illustrations. Paris: Masson et Cie, 1922.

This is a collection of fifty-six papers previously published by the author, generally in collaboration. They cover a wide range of subjects and are grouped under Fixation of Poisons of the Nervous System, Pathology of Cranial and Spinal Nerves, Muscular Atrophies, Spinal Fluid, Epidemic Encephalitis and Intoxications. Some of the articles are of especial value, and many are interesting. One might mention The Meningeal Form of Brain Tumor, Argyll-Robertson Pupils in Non-Syphilitic Lesions of the Cerebral Peduncles, Compression of the Cord in a Case of Recklinghausen's Disease, An Apnoeic Form of Tabetic Crisis, An Infectious Disease Characterized by Icterus and a Meningeal Syndrome, and The Medullary Form of the Sleeping Sickness (Trypanosomiasis).